FLUKE®

True-rms Multimeter

8060A

Instruction Manual

This manual pertains to instruments with serial numbers 6820xxx or higher.

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Instruction Manual

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Safety Information

This meter has been designed and tested in accordance with IEC Publication 348. To ensure that the meter is used safely, follow all safety and operating instructions in this manual. If the meter is not used as described in this manual, the safety features of the meter might be impaired.

- Do not use the meter if the meter or test leads look damaged, or if you suspect that the meter is not operating properly.
- Turn off power to the circuit under test before cutting, unsoldering, or breaking the circuit. Small amounts of current can be dangerous.
- Do not apply more than 500V rms between a terminal and earth ground.
- Use caution when working above 60V dc or 30V ac rms. Such voltages pose a shock hazard.
- When using the probes, keep your fingers behind the finger guards on the probes.
- Disconnect the live test lead before disconnecting the common test lead.

Symbols

The following international symbols are used in this manual:

Important Safety Information in Manual

AC

DC

Diode Test

Ground

Fuse

Indicates Terminals At Which Dangerous Voltages May Exist

Battery

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Chapter 1
Introduction and Specifications

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1-1. Introduction

Your Fluke Model 8060A is a handheld, microcomputer-based 4½ digit multimeter that is ideally suited for use in the field, laboratory, shop, or home. The 8060A has all the features that have become accepted standards for quality handheld multimeters, as well as some new features that have not been offered before in a handheld multimeter. New features include the following:

- True rms measurements for ac signals up to 100 kHz.
- Frequency measurements up to 200 kHz.
- Voltage measurements in dBm referenced to 600Ω or in dB relative to an operator-selected reference voltage.
- Resistance measurements up to 300 MΩ.
- Ability to store any input signal as an offset or relative reference value.

Other features include:

- Functions:

  All standard DMM measurement functions, such as ac and dc volts and ac and dc current, as well as resistance, conductance, continuity, and diode test.

- Ranges:

  Leading zero suppression.

  Automatic polarity.

  Overrange indication.

  Protection from overloads and transients up to 1500V peak.

  Dual-slope integration a/d conversion to ensure noise-free measurements.

  Autoranging MΩ resistance range (to 300 MΩ), as well as four fixed resistance ranges from 200Ω to 200 kΩ.

- Operator Convenience:

  4½ digit Liquid Crystal Display.

  Software-controlled self-test routines for quick verification of internal circuitry and operation.

- Power:

  170 hours of continuous operation can be expected from a 9V alkaline battery (NEDA 1604).

  Low battery voltage is automatically detected and displayed. The low battery indication, BT, appears on the display when about 20% of the battery life remains.

A full line of accessories is available to enhance the capabilities of the 8060A.

1-2. Items Furnished with Equipment

Items shipped with your True rms Multimeter are as follows:

- Battery
- DMM Accessory List
- Instruction Manual
- Operator Guide Card
- Registration Form
- Statement of Calibration
- Test Leads

1-3. Specifications

The specifications for the 8060A are listed in Table 1-1.

Table 1-1. 8060A Specifications

Electrical

The following specifications are based on a one-year calibration cycle, an operating temperature of 18 to 28°C (64 to 82°F) and a relative humidity not exceeding 80%.

DC Voltage

Range	Resolution	Accuracy ±(% of reading + no. of digits)
200 mV 2V	.01 mV .1 mV	0.04% + 2
20V 200V 1000V	1 mV 10 mV 100 mV	0.05% + 2

Response Time ..... 1 second maximum, to rated accuracy within selected range.

Input Impedance ..... 10 MΩ nominal

Normal Mode Noise Rejection ..... >60 dB at 50 Hz or 60 Hz

Common Mode Noise Rejection ... >120 dB at dc, >90 dB at 50 Hz and 60 Hz (1 kΩ imbalance)

Overload Protection ..... 1000V dc or peak ac continuous, except 20 seconds maximum on 200 mV and 2V ranges above 300V dc or rms.

DC Voltage, High Impedance Mode

All specifications are the same as for the dc voltage mode except the following (only 200 mV and 2V ranges are available):

Range	Resolutions	Accuracy ±(% of reading + no. of digits)
200 mV 2V	.01 mV .1 mV	0.05% + 2

Input Impedance ..... >1,000 MΩ, typically 10,000 MΩ

Overload Protection ..... 300V dc or rms continuous, 20 seconds maximum 300V to 1000V dc or peak ac.

Table 1-1. 8060A Specifications (cont)

DC Voltage, dB Mode

Measurements are made in dBm referenced to 600Ω or relative dB. All specifications are the same as for dc voltage except the following:

Dynamic Range..... With full .01 dB resolution, 99.79 dB. Total specified dynamic range is 136.22 dB (160 μV to 1000V).

Resolution and Accuracy ..... Depends on linear dc count (count refers to the display in dc volts independent of the decimal points - see table below).

Accuracy		
dBm Ref. 600Ω	**Range**	**Tolerance**
-74 to -56 (160 μV to 1.27 mV)	200 mV	±1 dB
-55.6 to -37.6 (1.28 mV to 10.23 mV)	200 mV	±.2 dB
-37.58 to -31.77 (10.24 mV to 19.99 mV)	200 mV	±.04 dB
-31.76 to -11.76 (20 mV to 199.99 mV)	200 mV	±.04 dB
-11.76 to -8.24 (.2V to 1.9999V)	2V	±.04 dB
8.24 to 28.24 (2.000V to 19.999V)	20V	±.04 dB
28.24 to 48.24 (20.00V to 199.99V)	200V	±.04 dB
48.24 to 62.22 (200.0V to 1000V)	1000V	±.04 dB

Linear Counts	Resolution	Accuracy
19.999 to 1024	.01 dB	±.04 dB
1023 to 128	.1 dB	±.2 dB
127 to 16	1 dB	±1 dB

Table 1-1. 8060A Specifications (cont)

AC Voltage (True rms, AC-Coupled)

Ranges..... 200 mV, 2V, 20V, 200V, 750V

Accuracy ..... ±(% of reading + no. of digits). See table below:

Input Voltage	Resolution	Range	20 Hz - 45 Hz*	45 Hz - 1 kHz*	1 kHz - 10 kHz*	10 kHz - 30 kHz*	30 kHz - 50 kHz*	50 kHz - 100 kHz*
20.0 - 199.99 mV	.01 mV	200 mV	1% + 10	0.2% + 12	0.2% + 20	0.5% + 40	1% + 100	3% +200
.2000 - 1.9999V	.1 mV	2V		0.5% +12	0.5% +20	1% +40	2% +100	
2.000 - 19.999V	1 mV	20V						
20.00 - 199.99V	10 mV	200V						
75.0 - 499.9V	100 mV	750V	Not Specified		Not Specified			
500.0 - 750.0V				1% +12				

* Not specified for input signals <10% of range.

Input Impedance ..... 10 MΩ shunted by <100 pF

Common Mode Noise Rejection ..... >60 dB at 50 Hz and 60 Hz (1 kΩ imbalance)

Crest Factor Range..... 1:1 to 3:1

Response Time..... Five seconds maximum to rated accuracy within selected range, 12 seconds to rated accuracy from an overload.

Overload Protection .... 750V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V rms or 300V dc. Input not to exceed a volt-hertz product of 10^7 (for example, 200V at 50 kHz).

Table 1-1. 8060A Specifications (cont)

AC Voltage, dB Mode (True rms, AC-Coupled)

Measurements are made in dBm referenced to 600Ω or relative dB. All specifications are the same as for ac voltage except the following:

Dynamic Range ... With full .01 dB resolution, 97.30 dBm. Total specified dynamic range is 109.72 dBm (2.45 mV to 750.0V ac rms).

Resolution ..... Depends on number of linear ac counts (count refers to the actual number on the display independent of the decimal point. See table below).

Linear Counts*	Resolution
19.999 to 1024 1023 to 128 127 to 16	.01 dB .1 dB 1 dB
*Not specified below 245 counts.	

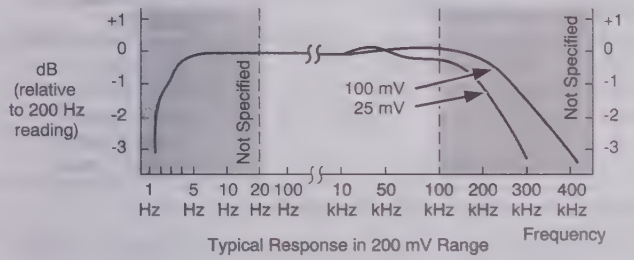
Accuracy ..... See table below:

dBm Ref. 600Ω	Range	20 Hz - 45 Hz**	45 Hz - 10 kHz**	10 kHz - 30 kHz**	30 kHz - 50 kHz**	50 kHz - 100 kHz**
-50.0 to -31.76 (2.45 mV to 20.00 mV)	200 mV	Not Specified				
-31.76 to -29.83 (20.00 mV to 25.00 mV)	200 mV	0.20 dB	0.50 dB	1.00 dB	2.20 dB	
-29.83 to -11.76 (25.00 mV to 199.99 mV)	200 mV	0.10 dB	0.15 dB	0.30 dB	0.50 dB	
-11.76 to 8.24 (.2000V to 1.9999V)	2V	0.10 dB*	0.10 dB*	0.15 dB*	0.30 dB*	0.50 dB*
8.24 to 28.24 (2.000V to 19.999V)	20V					
28.24 to 48.24 (20.00V to 199.99V)	200V	0.15 dB	0.30 dB	0.30 dB	0.65 dB	1.20 dB
48.24 to 59.72 (200.0V to 750.0V)	750V	20 Hz - 1 kHz**		1 kHz - 100 kHz**		
		0.5 dB		Not Specified		

*Specification applies above 8000 linear counts.
**Not specified for input signals <10% of range.

Table 1-1. 8060A Specifications (cont)

AC Voltage, dB Mode (cont.)



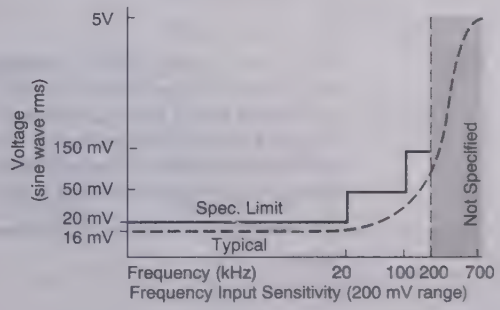
Typical Response in 200 mV Range

Frequency

Frequency Range (Fully Autoranging)	Resolution	Accuracy ±(% of reading + no. of digits)
200 Hz	.01 Hz	.05% + 1
2000 Hz	.1 Hz	
20 Hz	1 Hz	
200 Hz	10 Hz	

Input Signal	Sensitivity (based on sine wave V rms)
12 Hz to 20 kHz	20 mV or 10% of voltage range*
20 kHz to 100 kHz	50 mV or 25% of voltage range*
100 kHz to 200 kHz	150 mV or 75% of voltage range*

*Whichever value is greater.



Frequency Input Sensitivity (200 mV range)

Table 1-1. 8060A Specifications (cont)

Frequency (cont.)

AC Voltage Range	Maximum Useable AC Voltage*
200 MV	±5V peak
2V	±50V peak
20V	±500V peak
200V	±1000V peak
750V	±1000V peak

*Signal not to exceed a volt-hertz product of 1 x 10^7.

Input Characteristics ..... Ac-coupled, 10 MΩ shunted by <100 pF

Overload Protection ..... 759V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V rms or 300V dc. Input not to exceed a volt-hertz product of 10^7 (for example, 200V at 50 kHz).

Extended Frequency

Selection..... Enabled by holding down Hz button at power on.

Range..... 12 Hz to 700 kHz, typically.

Resolution ..... 100 Hz above 200 kHz.

Accuracy..... ±(0.5% of reading + 2 digits)

Sensitivity (sine wave V rms)..... Typically 100 mV at 200 kHz increasing to 4.5V at 700 kHz in the 200 mV range. Will measure a TTL signal (50% duty cycle) to 420 kHz, typically.

Resistance

Ranges..... 200Ω, 2 kΩ, 20 kΩ, 200 kΩ, autoranging MΩ. The MΩ range extends from .0001 mΩ to 300 MΩ in three autoranged ranges. Upscale range changes are made at 2 MΩ and 20 MΩ. Downscale range changes are made at 19 MΩ and 1.9 MΩ.

Accuracy ..... ±(% of reading + no. of digits). See table below.

Table 1-1. 8060A Specifications (cont)

Resistance (cont.)

Range		Reso-lution	Accuracy	Full-scale Voltage	Max Current	Open Circuit Voltage
200Ω		0.01Ω	(0.07%+2+.02Ω)	<250 mV	<1.1 mA	<4.8V
2 kΩ		0.1Ω	(0.07%+2)		<150 μA	<1.5V
20 kΩ		1Ω	(0.07%+2)		<15 μA	
200 kΩ		10Ω	(0.07%+2)		<1.5 μA	
MΩ	0-1.9999 MΩ	100Ω	(0.15%+2)	<2.5V	<2.5V	<2.5V
	2-19.99 MΩ	10Ω	(0.2%+3)			
	20-99.9 MΩ	100 kΩ	(1%+3)			
	100-300 MΩ	1 MΩ	(2%+3)			
Autoranging kΩ		0.1Ω to 1 kΩ	(0.2%+5)		<1.0 mA	

Response Time ..... Two seconds maximum to rated accuracy for all ranges except MΩ. For MΩ, 8 seconds maximum.

Overload Protection ..... 300V dc or rms ac for all ranges

Conductance

Range..... 2000 nS (equivalent to a resistance range from 500 kΩ to 10,000 MΩ)

Resolution ..... 0.1 nS

Accuracy ..... ±(0.5% of reading + 20 digits)

Open Circuit Voltage..... <1.5V

Overload Protection ..... 300V dc or rms ac

Table 1-1. 8060A Specifications (cont)

Continuity

Ranges	All resistance ranges
Threshold	Nominally 10% of range (for example, 20Ω in the 200Ω range) for 200Ω, 2 kΩ, 20 kΩ, 200 kΩ ranges. Nominally 20 kΩ in MΩ range.
Display Indication	Horizontal bar across the top of the display and/or 2.667 kHz tone. Indication is present for a minimum of 200 ms.
Response Time	50 μs maximum (10 μs typical)
Overload Protection	300V dc or rms ac

Diode Test

Range	2V
Test Current	1 mA (typical)
Accuracy	±(0.5% of reading + 2 digits) (Specification applies for voltage measurement)
Response Time	2 seconds maximum
Overload Protection	300V dc or rms ac

DC Current

Range	Resolution	Accuracy ±(% of reading + no. of digits)	Burden Voltage
200 μA	.01 μA	0.2% + 2	.3V typical
2 mA	.1 μA		.3V typical
20 mA	1 μA	0.3% + 2	.3V typical
200 mA	10 μA		.3V typical
2000 mA	100 μA		.9V typical

Overload Protection ..... 2A/250V fuse (operator replaceable) in series with 3A/600V fuse (service personnel replaceable).

Table 1-1. 8060A Specifications (cont)

AC Current (True rms Responding, AC-Coupled

Accuracy ..... ±(% of reading + no. of digits). See table below:

Input Current	Resolution	Range	20 Hz - 45 Hz	45 Hz - 3 kHz	3 kHz - 10 kHz	10 kHz - 30 kHz
20.00 to 199.99 μA	0.01 μA	200 μA	1% + 10	0.75% + 10	2% + 20	2% + 40
.2000 to 1.9999 mA	0.1 μA	2 mA				
2.000 to 19.999 mA	1 μA	20 mA				
20.00 to 199.99 mA	10 μA	200 mA				
200 to 1999.9 mA	100 μA	2000 mA			Not Specified	

Not specified for input < 10% of scale

Burden Voltage ..... 0.3V rms typical except 2000 mA range, 0.9V rms typical

Overload Protection ..... 2A/250V fuse (operator replaceable) in series with 3A/600V fuse (service personnel replaceable).

Relative

Selection ..... When the REL button is pushed, the input applied at that time is stored as a zero reference point. Subsequent readings indicate deviations (±) from the reference point.

Accuracy ..... Error does not exceed the sum of the errors of the reference reading and the subsequent reading.

Table 1-1. 8060A Specifications (cont)

General	
Maximum Common Mode Voltage	500V dc or ac rms
Display Update Rate	2.5 readings/second for all functions except frequency and dB. For frequency, 1 reading/second. For dB, 1.4 readings/second.
Electromagnetic Compatibility	In an RF field of 1 V/m on all ranges and functions: Total Accuracy = Specified Accuracy + 2.3% of range. Performance above 1 V/m is not specified.
Display	4½ digit duplex LCD (19,999 counts), leading zero suppression, autopolarity.
Display Annunciators	BT (low battery indicator), Hz or kHz (frequency unit), dB (dB function enabled), REL (relative function enabled). ➨➨ and))))) (continuity function enabled), and — (bar indicates continuity detected).
A/D Converter	Dual-slope converter
Power	Single standard 9V battery (NEDA 1604)
Battery Life	Typically 170 hours with an alkaline battery. BT appears on display when approximately 20% of battery life remains.
Size	180 mm L x 86 mm W x 45 mm H (7.1" L x 3.4" W x 1.8" H)
Weight	.41 kg (14.5 oz.)
Shock and Vibration	MIL-T-28800B

Table 1-1. 8060A Specifications (cont)

General (cont)	
Environmental	
Operating Temperature	0 to 50°C
Storage Temperature	-35 to + 60°C
Accuracy Temperature Coefficient	0.1 x the applicable accuracy specification per °C (plus the initial 23°C specification) for 0 to 18°C and 28 to 50°C.
Relative Humidity	0 to 80% R.H. from 0 to + 35°C, 0 to 70% from + 35°C to + 50°C, except 0 to 70% R.H. for MΩ range above 20 MΩ.
Safety	
Safety Standards	Designed to Protection Class II requirements of IEC 348, UL1244 ANSI C39.5 andCSA Bulletin 556B.
Certifications	UL

Chapter 2
Operating Instructions

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2-1. Introduction

This chapter describes how to make measurements with your 8060A. Even though you may have used a multimeter before, we suggest that you take the time to read this material carefully so that you can take full advantage of the wide variety of measurement functions offered by the 8060A.

2-2. Unpacking Your Instrument

Your instrument was shipped with two test leads (one red and one black), a 9V battery, and this manual. Check the shipment carefully and immediately contact the place of purchase if anything is missing or damaged in shipment.

If reshipment is necessary, please use the original shipping container. If the original container is not available, be sure that adequate protection is provided to prevent damage during shipment. It is recommended that the instrument be surrounded by at least three inches of shock-absorbing material in the shipping container.

2-3. Battery Installation or Replacement

The 8060A is designed to operate on a single, common, inexpensive 9V battery (NEDA 1604). When you receive the instrument, the battery will not be installed. You can expect a typical operating life of up to 170 hours with an alkaline batter, or 80 hours with a carbon-zinc battery. When the battery has exhausted about 80% of its useful life the BT indicator will appear at the far left of the display. Your instrument will continue to operate properly for at least 24 hours with an alkaline battery after BT first appears on the display. The 8060A also may be operated from a standard ac power line outlet when used with the optional A81 Battery Eliminator (refer to Chapter 7 for a description). Use the following procedure to install or replace the battery:

⚠ Warning

To avoid electrical shock, turn off the instrument and remove the test leads and any input signals before replacing the battery.

1. Set the 8060A power switch to OFF.
2. Remove test leads from external connections and from the 8060A input terminals.
3. Turn the instrument over and remove screw from battery cover as shown in Figure 2-1.
4. Use your thumbs to push off the battery cover as shown in Figure 2-1.
5. Slide the battery out of the compartment as shown in Figure 2-2.
6. Carefully pull the battery clip free from the battery terminals (if replacing the battery) and attach the new battery.
7. Slide the battery and its leads into the compartment and slide the cover into place.

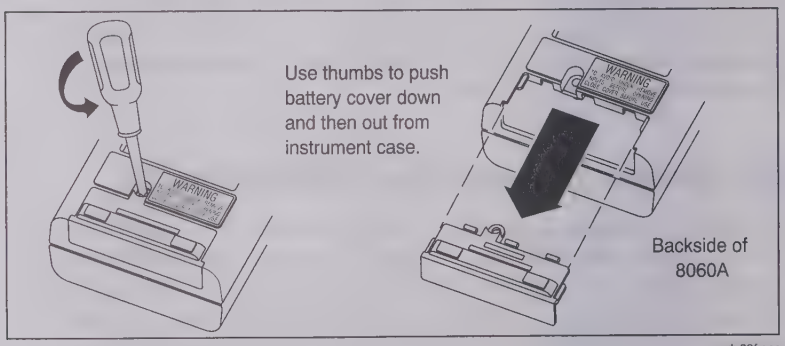

Figure 2-1. Removal of Battery Compartment Cover

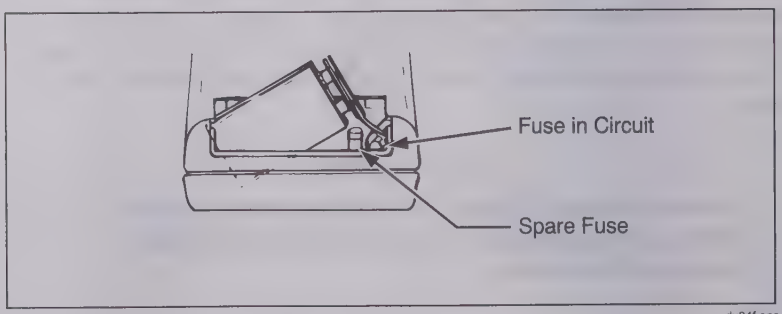

Figure 2-2. Battery Removal and Fuses

You can measure the voltage of your battery by using the following procedure:

1. Select the dc voltage function and the 20V range (refer ahead to Figure 2-6 if necessary).
2. Locate the opening for the battery eliminator jack on the right side of the instrument to the right of the display. Touch the red (VΩS) probe tip to the side contact (not the center pin). Be sure you do not short the battery by shorting the side contact to the center pin. Battery voltage should be between 5.2V to 10V for proper operation. If the voltage is less, the battery should be replaced.

2-4. Fuse Replacement

There are two fuses located at the right side of the battery compartment (refer to Figure 2-2 or examine your instrument). The fuse at the far right is F1. Fuse F1, 2A/250V, protects the current input from an input overload. The other fuse is a spare fuse for F1. When you purchase your instrument, F1 should be installed and the spare fuse should be in one of the two slots next to it. The larger slot is for the American-style fuse, and the smaller slot is for the European-style fuse (either style fuse fits in the installation compartment).

If you need to replace F1, use the tip of a test lead to push the fuse forward from the end and then up to release. Replace F1 with the appropriate 2A/250V fuse; American-style: fast-acting, type AGX2, 1/4 x 1", Fluke PN 376582; European-style: 5 x 20 mm, Fluke PN 460972. Do not use makeshift fuses or short-circuit the fuseholder.

There is another fuse, F2, 3A/600V, which also protects the current input. The instrument cover must be removed to replace F2. This procedure is described in Chapter 5 and should only be done by a person qualified to service the instrument.

The following steps provide a quick and easy way to check the condition of both fuses F1 and F2:

1. Select the resistance function and the 2 kΩ range.
2. Touch the red test lead tip to the A input jack so that the VΩS input and the A input are shorted together.
3. If the display reads .1000 ± .0100 kΩ, both fuses are good.
4. If the display reads OL, one or both fuses need replacement.

2-5. Physical Features

Before you begin using your 8060A, we suggest you take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are shown in Figure 2-3 and described in Table 2-1. The front panel and the display are also described in the following paragraphs.

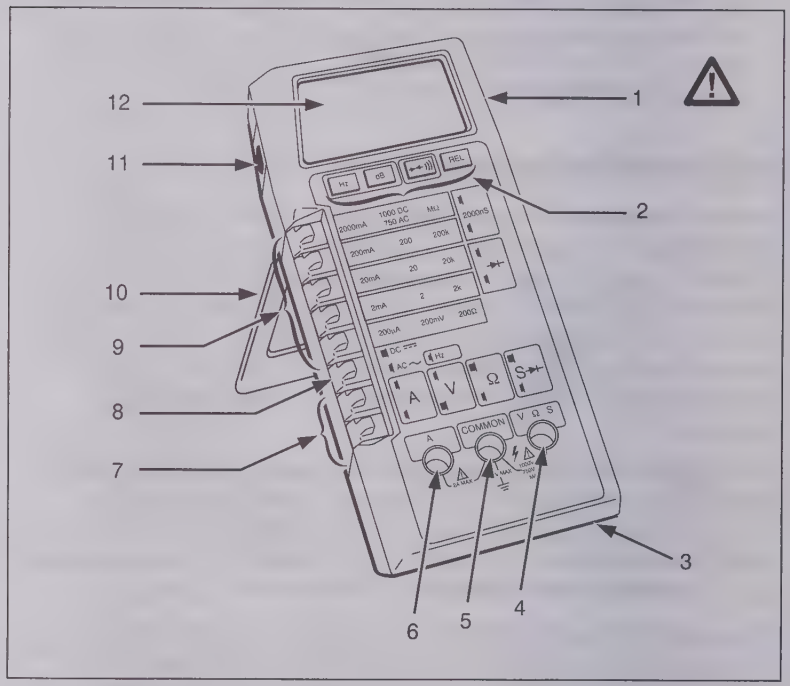

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Figure 2-3. Controls, Indicators and Connectors

2-6. Front Panel

The front panel of the 8060A is designed to make function and range selection easy. The symbols and colors on the panel indicate which switches to push or buttons to press to select the function you want. Details are provided later with the description of each function.

Table 2-1. Controls, Indicators and Connectors

Item No.	Name	Function
1 ⚠*	Battery Eliminator Connector	External input power connector for use with the A81 Battery Eliminator accessory.
2	Function Buttons: Hz, dB, ➡◀))), REL	Push buttons that toggle on or toggle off the 'secondary functions: frequency, dB, visible or audible continuity, or relative. These functions are selected in conjunction with the primary measurement functions (see items 7 and 8).
3	Battery Compartment and Cover	Cover for the 9V battery and the current fuse F1.
4	V Ω S Input Connector	Protected test lead connector used as the high input for all voltage, conductance, resistance, continuity, frequency measurements and diode test. All test lead connectors accept standard or safety-designed banana plugs.
5	COMMON Input Connector	Protected test lead connector used as the low or commom input for all measurements.
6	A Input Connector	Protected test lead connector used as the high input for current measurements.
7	Function Switches: A,V, Ω,S→|	Interlocked switches that are used in conduction with the input connectors to select the measurement functions. Pushing one switch releases the other, or both may be pushed together.
8	AC/DC Function Switch	Push-on/push-off switch is used to select ac or dc for current or voltage measurements. (Does not affect selection of diode test, resistance, or conductance functions).
9	Range Switches	Interlocked switches that are used to select ranges. Pushing a switch selects the corresponding range and released other switch depressions. Also used to select conductance and the diode test.
* For safe operation, fully insert the A81.		

Table 2-1. Controls, Indicators and Connectors (cont)

Item No.	Name	Function
10	Tilt Bail	A fold-out stand. The bail may also be removed (press on one of the legs at the hinge of the bail) and reinserted from the top as a hook for hanging the instrument.
11	Power Switch	Slide switch for turning instrument on or off.
12	Display	4½ digit LCD display (19999 maximum) with decimal point, minus sign, over-range, Hz, dB, continuity and relative indicators.

2-7. Display

The 8060A provides measurement results on the 4½ digit LCD display (refer to Figure 2-4 or your instrument). The decimal point is placed automatically. Symbols in the upper portion of the display indicate when one of the secondary functions is enabled. The unit for the autoranging frequency measurement is displayed automatically as Hz or kHz. The units for all the other measurements are indicated by the range switch that is pushed in. Leading zeros are not displayed.

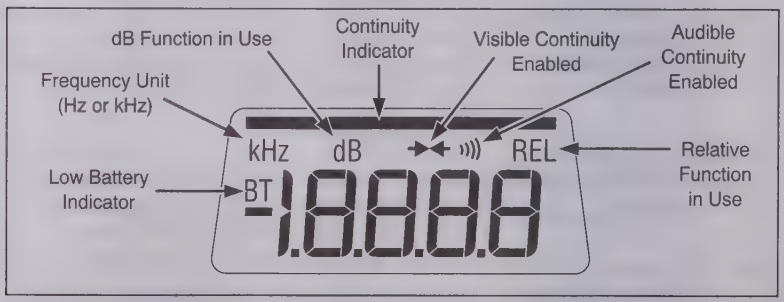

Figure 2-4. 8060A Display

If you are taking a measurement and the OL symbol appears on the display (Figure 2-5), an overrange condition is indicated, meaning that the input is higher than the range selected. You should select a higher range for the measurement. The OL symbol does not necessarily mean that the instrument is being exposed to a damaging input condition. For example, when measuring resistance, an open input will cause OL to appear.

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Figure 2-5. Overrange Indicator

2-8. Signal Input Limits

Caution

Exceeding the maximum input overload limits can damage your instrument.

Before you begin to use your 8060A, it is important to note the maximum inputs that may be applied to the instrument. Table 2-2 presents the maximum inputs that are allowed for each function, range, and input terminal.

⚠ Warning

To avoid electrical shock and/or instrument damage, do not connect the common input terminal to any source more than 1000 volts dc or rms ac above earth ground.

Table 2-2. Input Overload Limits

Function	Input Terminals	Maximum Input Limit
AC Voltage, AC dB, Frequency	VΩS and COMMON	750V rms or 1000V peak continuous except 20 seconds maximum on the 200 mV range above 300V dc or ac rms.
DC Voltage, DC dB	VΩS and COMMON	1000V dc or peak ac continuous except 20 seconds maximum on the 200 mV and 2V ranges above 300V dc or ac rms.
AC or DC Current	A and COMMON	2A maximum, fuse protected to 600V dc or ac rms.
Resistance, Conductance, Diode Test, and Continuity	VΩS and COMMON	300V dc or ac rms

2-9. Operation

The following paragraphs describe the power-on self-test, and how to operate your 8060A in each of the seven primary functions or the four secondary functions.

2-10. Power-On Self-Test

To turn on your instrument, locate the green switch on the left side of the instrument and slide it forward. Whenever you turn on the instrument, the 8060A automatically performs a self-test to make sure the display and the microcomputer are functioning properly. If everything is functioning properly, all the LCD segments in the display will turn on (Figure 2-4). After about one or two seconds, the display will go blank briefly before responding to switch selections.

If the LCD segments do not all turn on during the self-test, or if the instrument does not clear the display after the test and then respond to switch selections, something is probably wrong with the instrument. Try the test again, and if it fails, have a qualified person refer to Chapter 5. If there is no display when you turn on the instrument, check the battery and battery connections. You will find that if you turn off your instrument and then immediately turn it back on, a random assortment of LCD segments may be displayed. This is normal. After about a second the instrument should turn on all the LCD segments as usual during the self-test.

2-11. AC/DC Voltage (V)

Selection of the ac or dc voltage (V) functions is described in Figure 2-6. The 8060A offers five ac and five dc voltage ranges: 200 mV, 2V, 20V, 200V, and 750Vac/1000V dc. All ranges present a 10 MΩ input impedance, which is shunted by <100 pF in ac voltage measurements.

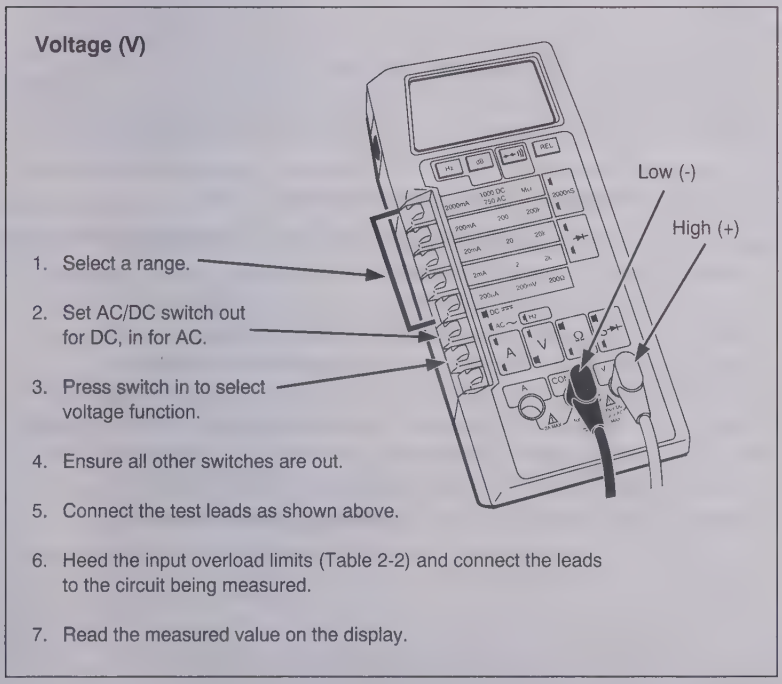
Voltage (V)
Low (-)
High (+)
1. Select a range.
2. Set AC/DC switch out for DC, in for AC.
3. Press switch in to select voltage function.
4. Ensure all other switches are out.
5. Connect the test leads as shown above.
6. Heed the input overload limits (Table 2-2) and connect the leads to the circuit being measured.
7. Read the measured value on the display.
dx08f.eps

Figure 2-6. Voltage Operation

2-12. True rms Measurement

One of the most useful features of the 8060A is the direct measurement of the True rms or effective ac voltages and ac currents. Mathematically, rms is defined as the square root of the sum of the squares of the ac and dc components. In physical terms, rms is equivalent to the dc value that dissipates the same amount of heat in a resistor as the original waveform. The reason that rms is so valuable is that it greatly simplifies the analysis of complex ac signals. Since rms is the dc equivalent to the original waveform, it can be used in the relationships derived from Ohm's law (E = I x R), and it provides a reliable basis for comparing dissimilar waveforms.

Most meters in use today have average-responding ac converters rather than true rms ac converters like the 8060A. Usually the gain in average-responding meters is adjusted so that the reading gives the rms value, provided the input signal is a harmonic-free sinusoid. However, if the signal is not sinusoidal, the average-responding meter does not give correct rms readings.

The 8060A ac converter actually calculates the rms value through analog computation. This means that 8060A readings are accurate rms values not only for harmonic-free sinusoids, but also for mixed frequencies, modulated signals, square waves, sawtooths, 10%-duty-cycle rectangular pulses, etc.

2-13. AC-Coupled AC Measurements

Input signals are ac-coupled in the ac functions. One of the major advantages of ac-coupling is that ripple measurements can be made on power supplies, phone lines, etc. Ripple measurements cannot be made with dc-coupling. Remember, however, that when the 8060A measures signals with the ac voltage function, the reading on the display does not include the dc component (if it exists). For example, consider the waveform in Figure 2-7. The ac voltage function will measure the ac rms component. The dc voltage function will measure the dc component. To obtain the total rms value for such a waveform, first measure the ac and dc values separately, then calculate the total rms value using the formula given in Figure 2-7.

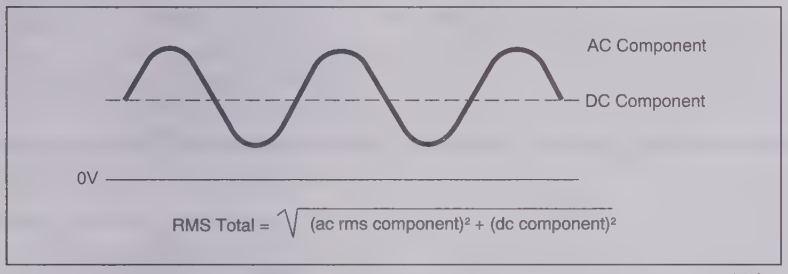

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Figure 2-7. AC and DC Waveform Components

2-14. Waveform Comparison and Conversion

Figure 2-8 shows the relationship between common waveforms and the display readings for the 8060A and average-responding meters. Figure 2-8 also illustrates the relationship between ac and dc measurements for ac-coupled meters. For example, consider the first waveform, a 1.414V (0-pk) sinewave. Both the 8060A and the rms-calibrated average-responding meter display the correct rms reading of 1.000V (the dc component equals 0). However, consider the 1.414V (0-pk) rectified square wave. Both types of meters correctly measure the dc component (0.707V). But only the 8060A correctly measures the ac component (0.707V). The average-responding meter measures 0.785V, which amounts to a 5.6% error in the total rms measurement calculated from the ac and dc components.

AC Coupled Input Waveform	Peak Voltages		Display Readings			DC and AC Total rms
			AC Component Only		DC Component only	TRUE RMS = $\sqrt{ac^2 + dc^2}$
	PK - PK	0 - PK	rms CAL*	8062A		
Sine	2.828	1.414	1.000	1.000	0.000	1.000
Rectified Sine (Full Wave)	1.414	1.414	0.421	0.435	0.900	1.000
Rectified Sine (Half Wave)	2.000	2.000	0.764	0.771	0.636	1.000
Square	2.000	1.000	1.110	1.000	0.000	1.000
Rectified Square	1.414	1.414	0.785	0.707	0.707	1.000
Rectangular Pulse D = X/Y K = $\sqrt{D - D^2}$	2.000	2.000	2.22K	2K	2D	$2\sqrt{D}$
Triangle Sawtooth	3.464	1.732	0.960	1.000	0.000	1.000

rms CAL is the displayed value for average responding meters that are calibrated to display rms for sine waves.

Figure 2-8. Multiplication Factors for Converting Waveforms

Since average-responding meters have been in use for so long, you may have accumulated test or reference data based on them. The conversion factors in Figure 2-8 should help you convert between the two measurement methods.

2-15. High Impedance DC Voltage

Occasionally you may want to make dc voltage measurements in high impedance circuitry where even the 10 MΩ input impedance for the normal dc voltage function could load the circuit and cause significant errors. For example, a 10 MΩ input impedance causes a 0.1% error when measuring the voltage across the 10 kΩ leg of a 90 kΩ over 10 kΩ voltage divider. The 8060A offers a >1,000 MΩ (typically >10,000 MΩ) input impedance dc voltage function which greatly reduces this error.

Figure 2-9 describes how to select the high input impedance dc voltage function (the ac voltage function does not operate in this mode). Notice that all of the function switches must be out to select this function. Either the 2V or the 200 mV range may be selected. Refer to Chapter 3 for more applications of this function, including a technique for using the 8060A as an electrometer to measure extremely low currents.

Note

When taking measurements in the high impedance dc voltage function, do not select any ranges except the 2V or 200 mV ranges. Measurement in other ranges will result in erroneous readings.

Note

When the high impedance dc voltage function is selected and no input is applied, noise from the environment (such as rf or power line noise) may cause the 8060A to display OL (overrange).

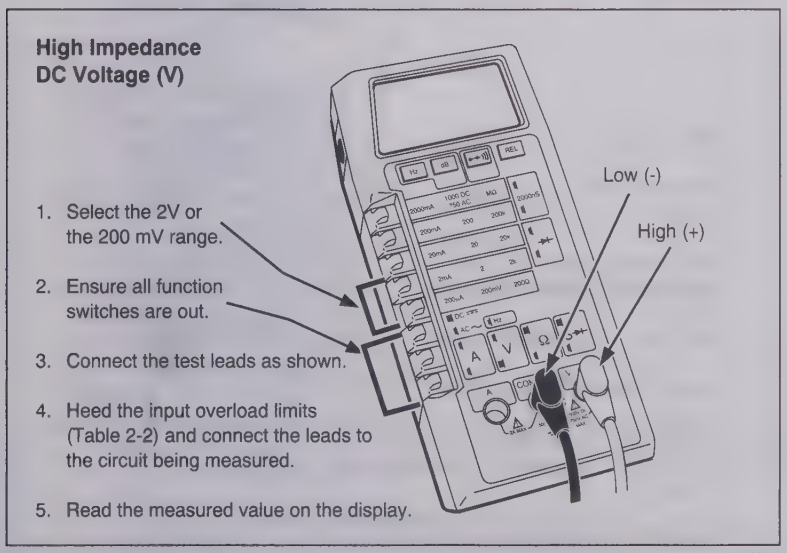
High Impedance
DC Voltage (V)
1. Select the 2V or the 200 mV range.
2. Ensure all function switches are out.
3. Connect the test leads as shown.
4. Heed the input overload limits (Table 2-2) and connect the leads to the circuit being measured.
5. Read the measured value on the display.
Low (-)
High (+)
dx10f.eps

Figure 2-9. High Impedance DC Voltage

2-16. AC/DC Current (A)

Selection of the ac or dc current (A) function is described is Figure 2-10. The 8060A offers five ac (true rms ac-coupled) and five dc current ranges: 200 µA, 2 mA, 20 mA, 200 mA, 2000 mA. Each range is protected by a 2A/250V fuse in series with a 3A/600V fuse.

When a meter is placed in series with a circuit to measure current, you may have to consider an error caused by the voltage drop across the meter (in this case, across the protective fuses and current shunts). This voltage drop is called the burden voltage. The maximum full-scale burden voltages for the 8060A are 0.3V for the four lowest ranges and 0.9V for the highest range.

These voltage drops can affect the accuracy of a current measurement if the current source is unregulated and the resistance of the shunt and fuses represents a significant part (1/1000 or more) of the source resistance. If burden voltage does present a problem, you can calculated the error by using the formula in Figure 2-11. You can minimize this error by selecting the highest current range that provides the necessary resolution.

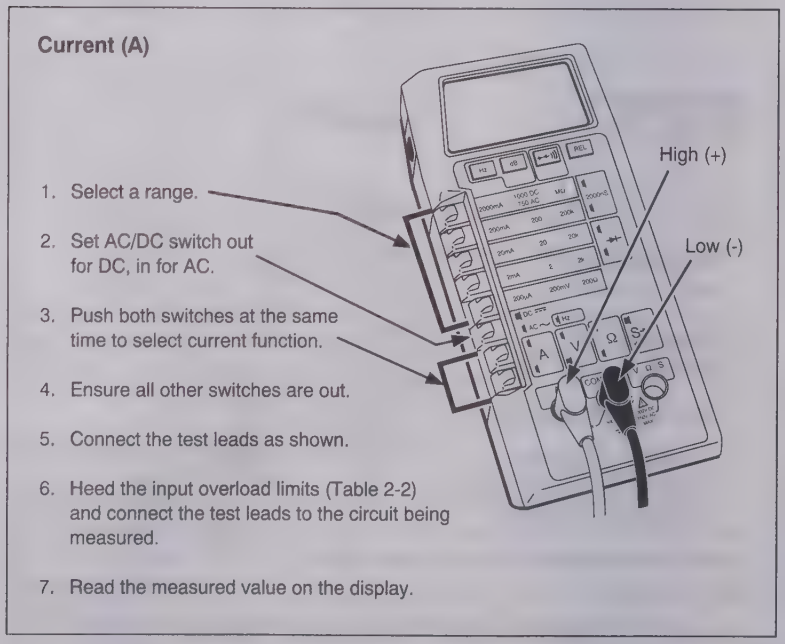
Current (A)
1. Select a range.
2. Set AC/DC switch out for DC, in for AC.
3. Push both switches at the same time to select current function.
4. Ensure all other switches are out.
5. Connect the test leads as shown.
6. Heed the input overload limits (Table 2-2) and connect the test leads to the circuit being measured.
7. Read the measured value on the display.
High (+)
Low (-)

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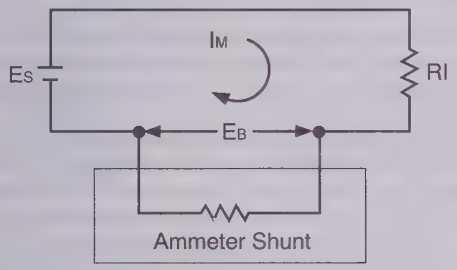
Figure 2-10. Current Operation



Es = Source Voltage
RI = Load resistance + Source resistance
Im = Measured current (display reading in amps)
Eb = Burden voltage (calculated)
Eb = meas. current [(200/current range in mA) + .35]

Error:

Error in % = 100 x Eb/(Es - Eb)
Error in A = (Eb x Im)/(Es - Eb)

Example:

ES = 15V
RI = 100 kΩ
Im = 148.51 μA (.14851 mA)

$Eb = 148.51 \times 10^{-6} \times [(200/.2) + .35]$

$= 148.51 \times 10^{-6} \times 1000.35 = 148.56$ mV

Max, error in % = 100 x [148.56 mV/(15V - .14856V)] = 1.0003%

Add this to the range spec. accuracy

Max. error in % = 1.0003% ±(.2% + 2 digits)

Max. error in A = (148.56 mV x 148.51 μA)/(15000 mV - 148.56 mV)

= 1.486 μA

Add 1.486 μA to the reading for correct current

Figure 2-11. Calculating Burden Voltage Error

2-17. Resistance (Ω)

Selection of the resistance function is described in Figure 2-12. There are four fixed ranges (200Ω, 2 kΩ, 20 kΩ, 200 kΩ) plus the autoranging MΩ range consisting of three ranges: 2 MΩ, 20 MΩ, and 300 MΩ.

In all fixed resistance ranges (200Ω to 200 kΩ), the test voltage is less than that required to turn on most semiconductor junctions. This feature, sometimes referred to as "low power" ohms, aids in troubleshooting by allowing you to measure resistors independent of the effects of in-circuit transistors and diodes. For the fixed ranges the maximum full scale voltage across the circuit being measured is less than 250 mV. The autoranging MΩ ranges have enough voltage to turn on semiconductor junctions (maximum 2.5V full scale), but the current is very low (2.2 μA maximum).

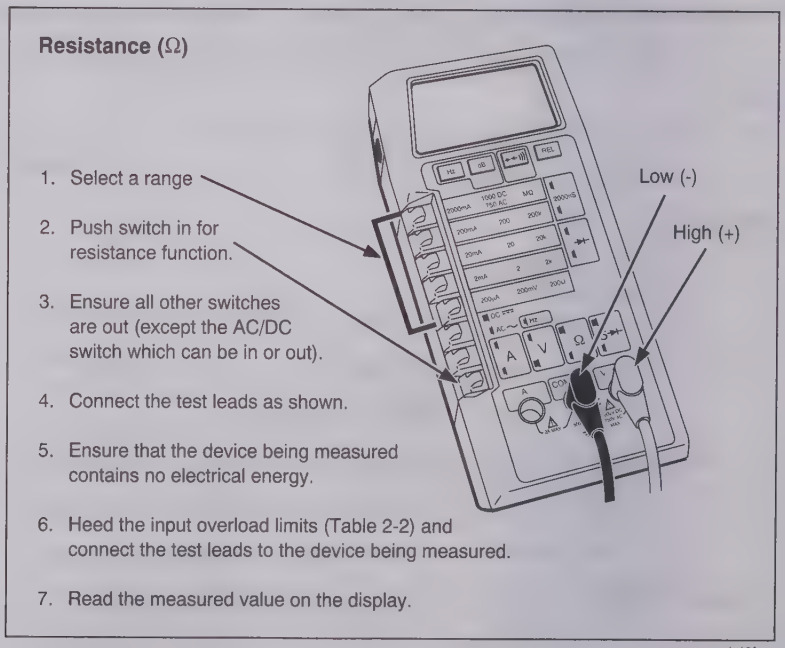

Resistance (Ω)
1. Select a range
2. Push switch in for resistance function.
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect the test leads as shown.
5. Ensure that the device being measured contains no electrical energy.
6. Heed the input overload limits (Table 2-2) and connect the test leads to the device being measured.
7. Read the measured value on the display.
Low (-)
High (+)
dx13f.eps

Figure 2-12. Resistance Operation

Resistance measurements for all ranges are made using a two-wire ratiometric technique. This means that test lead resistance may affect the accuracy in the 200Ω range. You can correct this error by shorting the test leads together, reading the test lead resistance, and then subtracting it from resistance readings. The most convenient way to do this is with the relative function as described later in this chapter. This technique is also useful for removing the 0.02Ω error factor in the 200Ω range (refer to resistance specifications in Chapter 1).

2-18. Autoranging Megohms

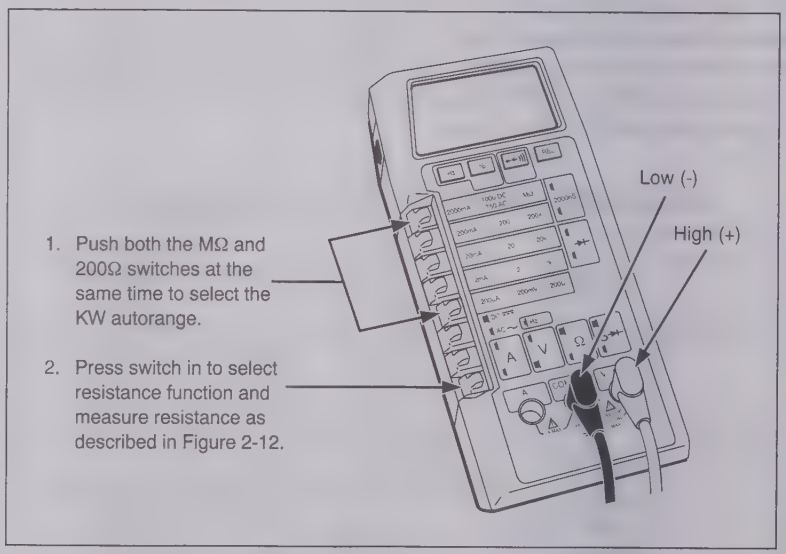
When the autoranging MΩ range is selected, the 8060A automatically selects the range appropriate for the measurement. The measurement resolution decreases in the two higher MΩ ranges as shown in Table 2-3. Readings made at the crossover points between ranges are microcomputer-stabilized by an offset in the upscale and downscale directions. Range changes are made at 2.00 MΩ and 20.00 MΩ as readings go upscale, or at 19.0 MΩ and 1.90 MΩ as readings go downscale.

Table 2-3. Resistance Function Autoranges and Resolution

Range			Resolution	No. of Digits Possible in Reading
MΩ Autorange	2 MΩ		100Ω	4½
	20 MΩ		10 kΩ	3½
	300 MΩ	20 to 99.9 kΩ	100 kΩ	3
		100 to 300 MΩ	1 MΩ	3
kΩ Autorange	2 kΩ		0.1Ω	4½
	20 kΩ		10Ω	3½
	300 kΩ	20 to 99.9 kΩ	100Ω	3
		100 to 299 kΩ	1 kΩ	3

2-19. Autoranging Kilohms

Although it is not indicated on the front panel, there is an additional autoranging range available: the autoranging kΩ range, which consists of 2 kΩ, 20 kΩ, and 300 kΩ. To select this range, you must simultaneously press the MΩ and the 200Ω switches as shown in Figure 2-13. Like the autoranging MΩ ranges, the autoranging kΩ ranges have enough voltage to turn on semiconductor junctions. Note that the use of the relative function with the autoranging kΩ ranges is restricted to the autoranging kΩ ranges. Refer to the description of the relative function for more information. The autoranging kΩ has the same decrease in resolution (see Table 2-3) and the same display hysteresis as the autoranging MΩ.


1. Push both the MΩ and 200Ω switches at the same time to select the KW autorange.
2. Press switch in to select resistance function and measure resistance as described in Figure 2-12.
Low (-)
High (+)

dx14f.eps

Figure 2-13. Selection of Autoranging Kilohms

2-20. Conductance (S)

Selection of the conductance function is described in Figure 2-14. The range is 2000 nS (nS = nanosiemens or 10^{-9} siemens, 1 siemen = 1 Ω) which corresponds to a resistance range from 500 kΩ to 10,000 MΩ.

Conductance is a good way to measure high resistances, such as leakages in diodes, capacitors, pcbs, or insulators. For example, you can measure the conductance of a pcb and then covert the measurement to resistance by referring to Figure 2-15. If you are measuring the leakage of a capacitor, be sure to discharge it first by shorting its leads together. The positive (+) lead of polarized capacitors should be connected to the VΩS input.

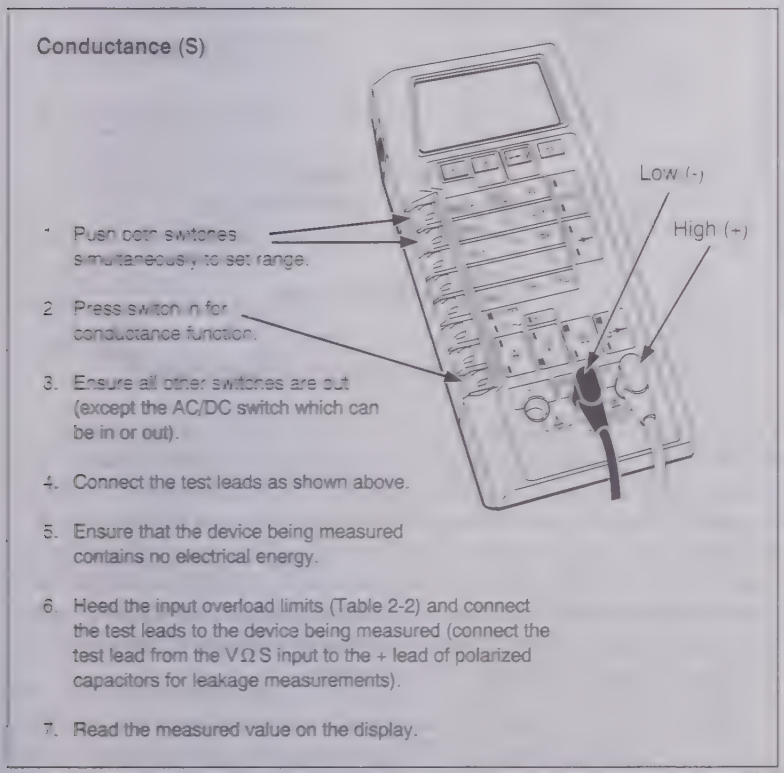

Conductance (S)
Low (-)
High (+)
1. Push both switches simultaneously to set range.
2. Press switch in for conductance function.
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect the test leads as shown above.
5. Ensure that the device being measured contains no electrical energy.
6. Heed the input overload limits (Table 2-2) and connect the test leads to the device being measured (connect the test lead from the VΩS input to the + lead of polarized capacitors for leakage measurements).
7. Read the measured value on the display.
dx15f.eps

Figure 2-14. Conductance Operation

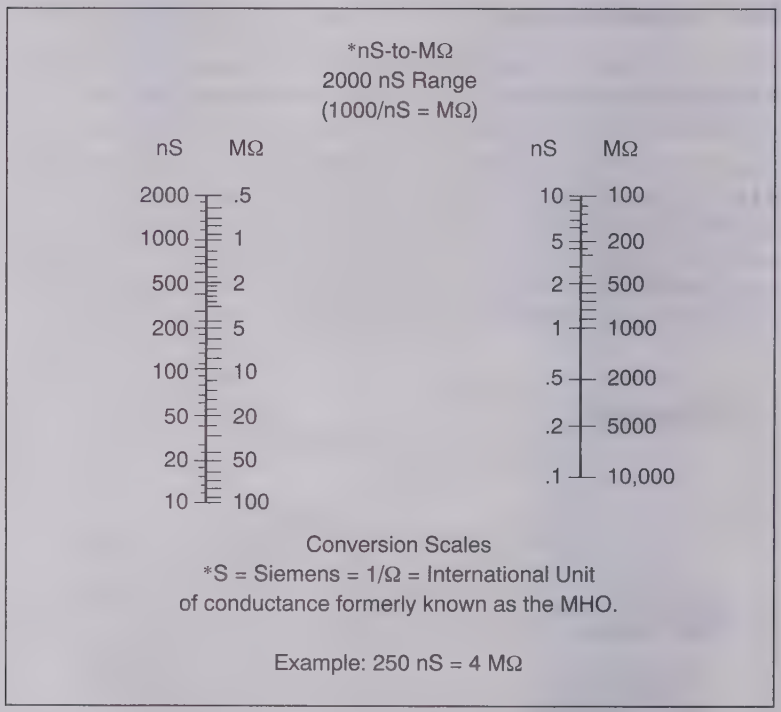


Figure 2-15. Conductance/Resistance Conversion

You may encounter situations where conductance is more convenient to measure than resistance. For example, the resistance of a photodiode is inversely proportional to the available light, i.e. as light increases, resistance decreases. This might be confusing if you want to examine the response of the component over a range of values. However, since conductance is the reciprocal of resistance, photodiode conductance is directly proportional to available light. As light increases, conductance increases. It might be easier to examine the photodiode response in terms of conductance, and then covert the measurements to resistance values if desired.

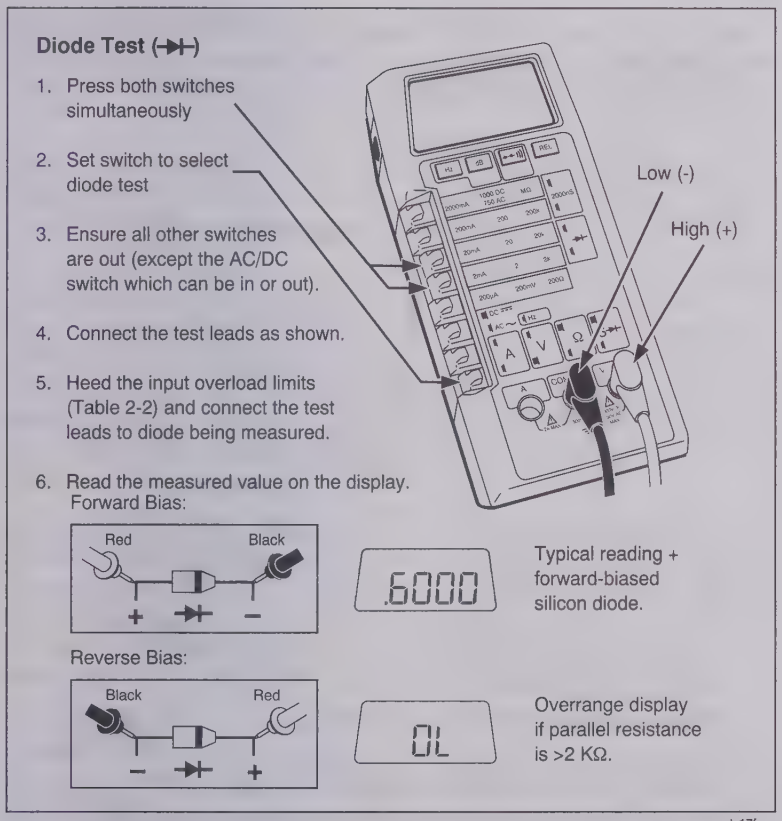

Diode Test (→|←)
1. Press both switches simultaneously
2. Set switch to select diode test
3. Ensure all other switches are out (except the AC/DC switch which can be in or out).
4. Connect the test leads as shown.
5. Heed the input overload limits (Table 2-2) and connect the test leads to diode being measured.
6. Read the measured value on the display.
Low (-)
High (+)
Forward Bias:
Red
Black
+
−
.6000
Typical reading + forward-biased silicon diode.
Reverse Bias:
Black
Red
−
+
OL
Overrange display if parallel resistance is >2 KΩ.
dx17f.eps

Figure 2-16. Diode Test

2-21. Diode Test (→|←)

Selection of the diode test is described in Figure 2-16. Notice how the test leads are placed to forward-bias or reverse-bias the diode in the figure.

The diode test measures the forward voltage of a semiconductor junction (or junctions) at a 1 mA test current. Readings are displayed in the 2V range, with OL displayed for voltages greater than 2V. For a silicon diode, the typical forward voltage at 1 mA is about 0.6V. A reverse-biased semiconductor junction should display the overrange (OL) indicator provided that any resistance parallel to the junction is greater than 2 kΩ.

A quick way to check for shorted or open junctions is to reverse the test leads. If the junction indicates the same in-scale reading both directions, it is probably shorted. If the junction indicates an overrange both directions, it is open.

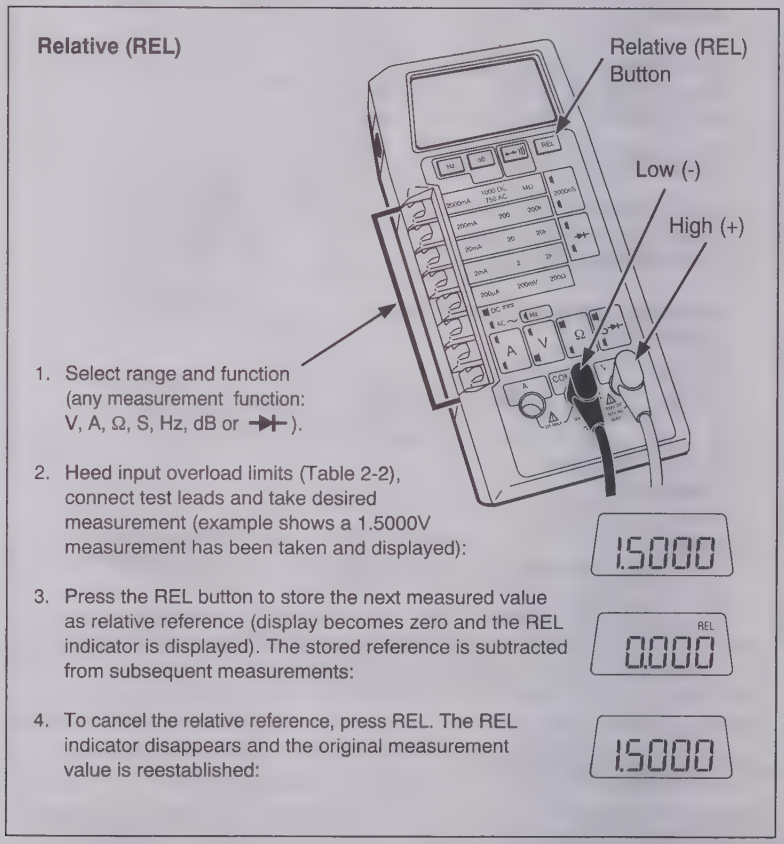

Relative (REL)
Relative (REL) Button
Low (-)
High (+)
1. Select range and function (any measurement function: V, A, Ω, S, Hz, dB or ⊣⊢).
2. Heed input overload limits (Table 2-2), connect test leads and take desired measurement (example shows a 1.5000V measurement has been taken and displayed):
1.5000
3. Press the REL button to store the next measured value as relative reference (display becomes zero and the REL indicator is displayed). The stored reference is subtracted from subsequent measurements:
REL
0.000
4. To cancel the relative reference, press REL. The REL indicator disappears and the original measurement value is reestablished:
1.5000
dx18f.eps

Figure 2-17. Relative (REL) Operation

2-22. Relative (REL)

The relative function allows you to store any reading as an offset or relative reference value. When you press the REL button, the REL indicator appears in the upper right corner of the display, and the 8060A stores the next measurement in a register along with the function and range. Subsequent measurements are displayed as the difference between the measured value and the stored relative reference (refer to Figure 2-17).

For example, if a reading of 1.0000V dc is displayed when the REL button is pressed (the display will read 0.0000 after REL is pressed), subsequent readings will have 1.0000 subtracted from them. If the next measurement is 1.2700V dc, the reading displayed will be .2700. If the next measurement is 0.8500V dc, the reading displayed will be -.1500. You may cancel the relative reference by pressing the REL button (the REL indicator disappears from the display), by turning the instrument off, or by storing a relative reference with another function.

If you change ranges, the relative reference is automatically multiplied or divided by the appropriate power of ten before being subtracted from the measurement. If you change functions, the REL indicator disappears and the relative reference is stored with the original function. When you reselect the function, the relative reference is restored (the REL indicator reappears) unless a new relative reference was established in another function.

The relative function may be used with all the measurement functions: ac or dc voltage, ac or dc dB, ac or dc current, resistance, conductance, diode test, and frequency. When used with continuity, the relative function stores the accompanying resistance readings. Note that the input overload limits are not changed by the use of the relative function.

Another thing to be aware of when using relative reference is that the range of possible readings is still subject to the limits of the display and the 19999 counts of the analog-to-digital (a/d) converter, regardless of the relative reference. For example, suppose the instrument is in the dc voltage function with the 20V range selected, and you store a relative reference of 15V. The maximum positive relative voltage reading that can be displayed without overranging is 4.999V, which is actually a 19.999V input signal. Any input signal greater than 19.999V exceeds the 19999 counts of the a/d converter. The minimum (negative) voltage reading that may be displayed without overranging is -19.999V, which is a -4.999V input signal. You can avoid this situation by selecting a higher range.

Remember that even though the REL indicator appears on the display almost instantaneously after the REL button is pressed, the relative reference is not stored until the next measurement takes place. For most functions, the time between measurements is about 0.4 seconds (frequency measurements occur every second, and dB measurements occur about every 1.4 seconds).

A typical way to use the relative reference is to correct for test lead resistance. Although test lead resistance is usually very small (typically 0.5 to 5Ω), it can be significant when measuring low resistances. To correct for it, select the desired resistance range, short the test leads together, and press the REL button. The REL indicator will appear and the display will read zero. The 8060A will automatically subtract the stored test lead resistance from subsequent measurements. Other common applications for relative reference include: offset nulling (dc and ac voltage or current), amplifier matching (dB), power line frequency deviation (Hz), diode and transistor matching (diode test), resistor matching (Ω), and voltage deviation (ac and dc voltage).

Note

The use of the relative function with the autoranging kΩ ranges is restricted to the autoranging kΩ ranges. If you take a reference reading within the autoranging kΩ range and then use it as a reference outside autoranging kΩ, or use a reference reading taken outside autoranging kΩ within autoranging kΩ, errors will result. There is no restriction on the use of the relative function with the fixed resistance ranges or with autoranging MΩ.

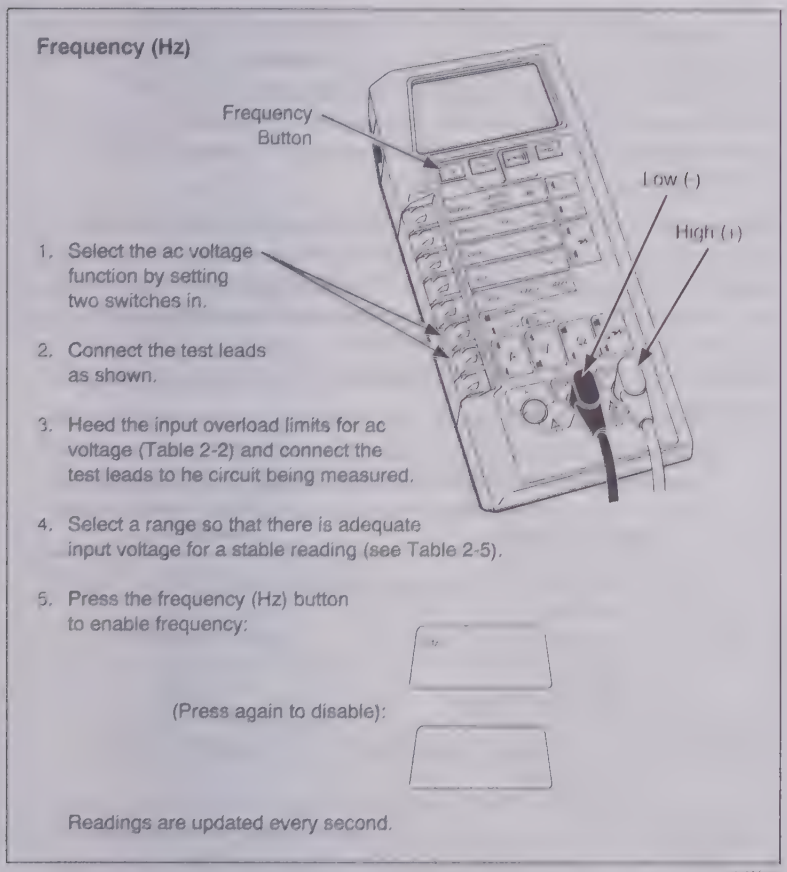

Frequency (Hz)
Frequency Button
Low (-)
High (+)
1. Select the ac voltage function by setting two switches in.
2. Connect the test leads as shown.
3. Heed the input overload limits for ac voltage (Table 2-2) and connect the test leads to he circuit being measured.
4. Select a range so that there is adequate input voltage for a stable reading (see Table 2-5).
5. Press the frequency (Hz) button to enable frequency:
(Press again to disable):
Readings are updated every second.
dx19f.eps

Figure 2-18. Frequency (Hz) Operation

2-23. Frequency (Hz)

The selection of the frequency function is described in Figure 2-18. Frequency selection is canceled if you select a different function (resistance or ac voltage dB, for example).

The frequency function is fully autoranging over four ranges: 200 Hz, 2000 Hz, 20 kHz, and 200 kHz. Depending on the frequency of the ac input signal, the 8060A automatically selects the proper range and displays the appropriate measurement unit, either Hz or kHz. Frequencies less than 12.2 Hz are not measured reliably, and frequencies greater than 199.99 kHz cause the OL overrange indicator to appear.

When you press the Hz button to select the frequency function, the Hz indicator appears in the display almost immediately, and the first frequency reading is displayed within one second. The 8060A has a one-second reading rate for all ranges (except for frequencies between 12 and 16 Hz, which respond in 1 to 1.3s), including the .01 Hz and .1 Hz resolution readings in the 200 Hz and 2000 Hz range. The resolution for each range is listed in Table 2-4.

Table 2-4. Frequency Function Autoranges and Resolution

Frequency Range	Resolution
200 Hz	.01 Hz
2000 Hz	.1 Hz
20 Hz	1 Hz
200 Hz	10 Hz
>200 kHz Extended Range*	100 Hz
*Extended range enabled by holding down the Hz button at power-on.	

The minimum input signal that is required to trigger the frequency counter varies, depending on the ac voltage range selected and the frequency. The input signal sensitivity is listed in Table 2-5. The values are based on rms sine waves. You must increase the signal level for lower crest factor input signals (the crest factor is the ratio of the peak voltage to the ac rms voltage of a waveform) or non-50% duty-cycle signals. If the input signal is below the required level, the 8060A will display 0.00 Hz, and will not take readings. If you find that your readings are unstable, the input signal may be near the threshold level for that range. You can correct this by selecting a lower ac volts range.

Table 2-5. Sensitivity for the Frequency Function

Input Signal	Sensitivity (based on sine wave V rms)
12 Hz to 20 kHz	20 mV or 10% of voltage range*
20 kHz to 100 kHz	50 mV or 25% of voltage range*
100 kHz to 200 kHz	150 mV or 75% of voltage range*
*Whichever value is greater.	

The maximum input voltage that may be applied depends on the ac voltage range. The maximum inputs are listed in Table 2-6.

Caution

No voltage overrange indication is given when the 8060A is measuring frequency. To prevent possible instrument damage, do not exceed 750V ac rms or a volt-hertz product of 1 x 10^7 when measuring frequency.

Table 2-6. Maximum Input Voltages for the Frequency Function

AC Voltage Range	Maximum Useable AC Voltage*
200 mV	±5V peak
2V	±50V peak
20V	±500V peak
200V	±1000V peak
750V	±1000V peak
*Signal not to exceed a volt-hertz product of 1 x 10^7.	

In addition to the four usual frequency ranges, there is an extended frequency range that may be enabled. To enable the extended frequency range, hold down the Hz button as you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the Hz button. Now when you select the frequency function, the autoranging can extend beyond the 200 kHz range. The 200 mV ac voltage range is recommended for frequencies above 200 kHz. Normally this frequency range is not enabled because of loss of sensitivity above 200 kHz, but typically you can measure 420 kHz TTL level signals (50% duty cycle). When the instrument is turned off, the extra range is disabled.

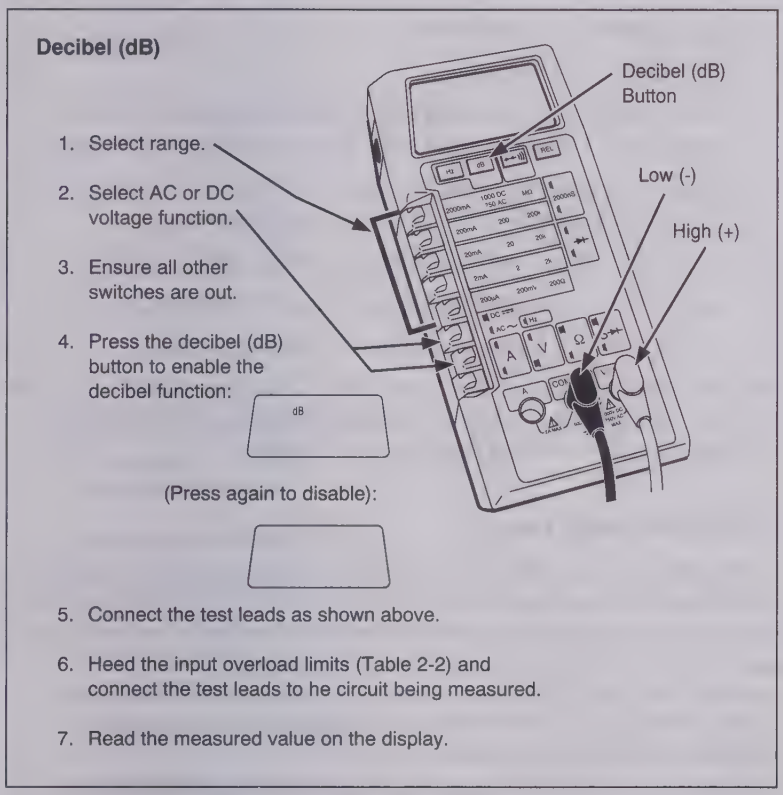
2-24. Decibel (dB)

The selection of dB is described in Figure 2-19. Like frequency, dB is automatically canceled if you select another function (resistance or frequency, for example).

When dB is selected, the 8060A microcomputer converts ac or dc voltage readings to the dBm equivalent (decibels above or below one milliwatt). The standard reference impedance is 600Ω. You can make dB measurements independent of the reference impedance by using the relative function in conjunction with the dB function. You can also modify the reference impedance by applying and storing a voltage equivalent to 0 dBm referenced to the desired impedance. Refer to Chapter 3 for details.

Note that the 8060A performs a 'bridging' measurement when measuring dBm, which assumes the reference load is part of the system. When making 'terminating' measurements (such as testing a phone line without a phone connected) be sure to apply the proper load to the 8060A. For example, if you are making a terminating dBm measurement in a 600Ω system with 50V maximum signal levels, place a 600Ω 5 watt resistor across the 8060A input terminals.

The ac dB dynamic range is from -50.0 to 59.72 dBm (109.72 dBm total). The dc dB dynamic range is from -74 to 62.22 dBm (136.22 dBm total). For readings greater than approximately 5% of full-scale for the voltage range selected, the resolution is .01 dB. Below approximately 5% of scale, resolution drops off to .1 dB, and below approximately 0.6% of scale, resolution is 1 dB. Anytime blank digits appear to the right of the decimal point, it is an indication that resolution has fallen off and you need to select a lower range.


Decibel (dB)
Decibel (dB) Button
Low (-)
High (+)
1. Select range.
2. Select AC or DC voltage function.
3. Ensure all other switches are out.
4. Press the decibel (dB) button to enable the decibel function:
dB
(Press again to disable):
5. Connect the test leads as shown above.
6. Heed the input overload limits (Table 2-2) and connect the test leads to he circuit being measured.
7. Read the measured value on the display.

dx20f.eps

Figure 2-19. Decibel (dB) Operation

2-25. dBV

dBV is defined as dB relative to 1 volt, independent of load impedance. This measurement is commonly used in the audio industry as a convenient reference for log weighted measurements such as noise, sensitivity, and level. The 8060A uses the ratio self-test to "fool" the microcomputer into thinking it has 1V present at the meter input, and then uses the pseudo 1V as the 0 dB relative reference. Use the following procedure to make dBV measurements:

1. Turn the 8060A power switch off.
2. Select Volts, AC, 2V range.
3. Turn the power switch on while holding down the continuity button. When the .8.8.8.8 display appears, the power-on self-test is complete.
4. Release the continuity button. The display should now read -.9990 to -1.0010. The instrument is now in the ratio self-test mode.
5. Push the dB button. The display should read 2.21 dB to 2.22 dB.
6. Push the REL button. The display should read 0.00 dB REL.
7. Push the continuity button again to cancel the ratio self-test.

The meter will now make all subsequent dB measurements in dBV as long as the power remains on and the REL button is not used again. All other meter functions can be used without losing the dBV function.

2-26. Continuity (➨◀))))

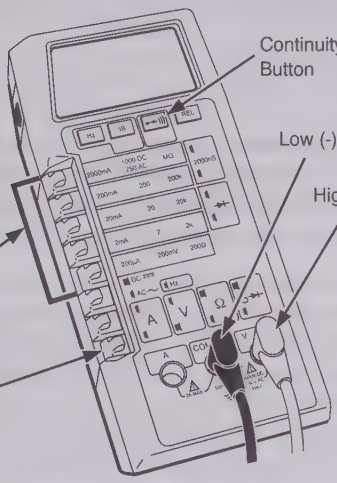
To select the continuity function, first select the resistance function and then press the ➨◀))))) button under the display. The ➨◀))))) button functions like a three-position switch: the first button press enables visible continuity (the ➨◀ indicator is displayed), the second button press enables audible continuity (the ➨◀))))) indicator is displayed), and the third button press cancels continuity selection (the ➨◀))))) disappears). The selection of continuity is summarized in Figure 2-20.

When continuity is detected, visible continuity is indicated by the long bar across the top of the display. Audible continuity (if enabled) is indicated by the tone emitted from the instrument.

Continuity is a quick check to verify whether circuit connections are intact. The continuity detection threshold is typically <10% of the resistance range selected for the fixed ranges (i.e. continuity is detected if resistance is less than 20Ω in the 200Ω, less than 200Ω in the 2 kΩ range, etc.). The detection threshold is <20Ω for the autoranging kΩ range, and 20 kΩ for the autoranging MΩ range.

The 8060A can detect continuity for intervals as brief as 50 µs (typically as brief as 10 µs). It extends the visible or audible indication to a minimum of 200 ms to make it easy for you to see or hear the results. Note that while continuity is enabled, the 8060A still makes resistance measurements and displays the readings.

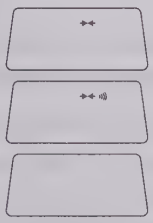
Continuity (→◄)



1. Select range.
2. Set switch in for resistance function.
3. Ensure that other switches are out.
4. Press the →◄))) button once to enable visible continuity:

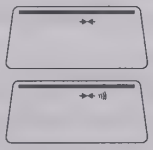
   Press the →◄))) button again to enable audible continuity:

   (Press again to disable both):



5. Connect the test leads as shown.
6. Ensure that the device being measured contains no electrical energy. Heed the input overload limits (Table 2-2), and connect the test leads to the circuit.
7. Observe the display for visible continuity indicated by the bar:

   Or listen for tone indicating audible continuity:



dx21f.eps

Figure 2-20. Continuity (→◄) Operation

2-27. Initial Check-Out Procedure

Here is an easy procedure you can use to verify that your 8060A is operating properly for most functions. All you need to perform these tests are the test leads and access to a standard wall socket. Remember that you are not trying to verify the instrument accuracy, but are simply confirming that the functions work. Performance tests and calibration adjustments are presented in Chapter 5. If the instrument passes the self-test when the instrument is first turned on, then the display and the microcomputer are working properly.

1. DC Voltage - Select the dc voltage function and the 20V range. Read the battery voltage by touching the probe tip from the lead connected to the VΩS jack to the side contact (not the center pin) in the opening for the battery eliminator jack on the right side of the instrument. Be careful not to short the battery by connecting the side contact to the center pin. Battery voltage should read 5.2V to 10V. If the voltage is less than 5.2V, the battery should be replaced.

   ⚠ Warning

   Be careful not to touch the probe tips with your fingers, or to allow the probe tips to contact each other.

   The local line voltage is measured in the following step.

2. AC Voltage, dB, Frequency - Select the ac voltage function and the 200V range. Take note of the preceding warning and insert the probe tips into a standard wall socket. The display should read the local line voltage.

   Now push the dB button. The display should read the line voltage in dB.

   Now push the Hz button. The display should read the frequency of the line voltage. Carefully remove the probe tips from the wall socket.

3. Resistance, Continuity, Conductance, Diode Test - Select the resistance function and the 2 kΩ range. Touch the red (VΩS) probe tip to the A jack so the VΩS input is shorted to the A input (this is the fuse check procedure from section 2-4). The display should read .1000 ± .0100 kΩ (neglecting lead resistance).

Push the ➡◀))) button twice to enable the visible and audible continuity. You should see the bar in the display and hear the tone.

Select the diode test (with the VΩS and A inputs still shorted together). The display should read .0102 ±.0015V.

Select the conductance function (with the VΩS and A inputs still shorted together). The instrument should indicate overrange (OL). Remove the connection between the inputs. The instrument should indicate 0.0 ±1.0.

Chapter 3
Applications

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3-1. Introduction

With its unique combination of features such as true rms, frequency, dB, relative reference and the 4½ digit display, the 8060A offers a wide variety of measurement capabilities, including measurement of amplifier bandwidth, the Q factor, amplifier stage gain in relative dB, and some other general audio applications. You can also find out how to change the dB reference impedance or how to use the 8060A to measure extremely low currents. These applications may be of immediate use to you, or they may help you discover other ways the 8060A can fill your measurement needs.

3-2. Determining Amplifier Bandwidth

The following procedure describes how to use the ac voltage dB, relative, and frequency functions to determine the bandwidth of an amplifier (for frequencies up to 100 kHz):

1. Connect the amplifier, signal generator, load, and 8060A as shown in Figure 3-1.
2. On the 8060A, select the ac voltage function and a range appropriate for the amplifier output.
3. Adjust the signal generator for a signal level that is within the input operating range of the amplifier. Beginning at a low frequency (20 Hz), steadily increase the frequency until the ac voltage reading on the 8060A begins to rise. Typically the ac voltage reading will rise to a peak, level out, and then begin to fall, much like the response curve shown in Figure 3-1. (High quality audio amplifiers will probably not show a rise in readings since they are generally flat from 20 Hz to >20 kHz. In this case, use 1 kHz as a midband reference for 0 dB in Step 4.)
4. When the peak or the upper plateau of ac voltage readings has been reached, press the dB button and then the REL (relative) button on the 8060A. This establishes the 0 dB relative reference.

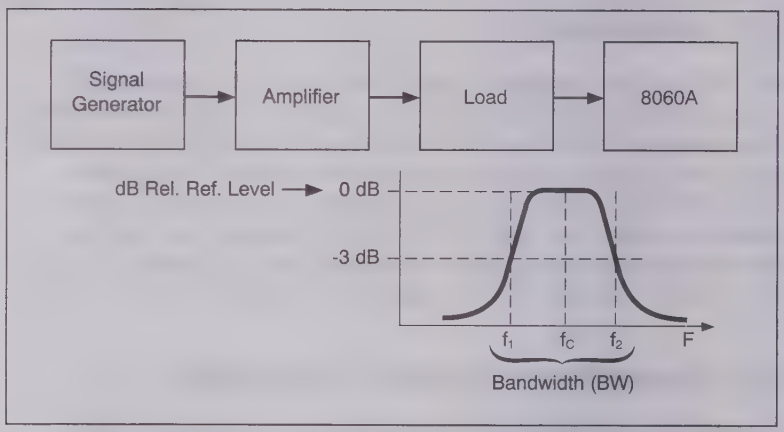

Figure 3-1. Measuring Amplifier Bandwidth

5. Increase the frequency input until the dB readings drop to -3.00 dB. Press the Hz button on the 8060A to read the upper frequency limit of the bandwidth. Press the dB button to restore the dB reading.

6. Decrease the frequency input so the dB readings rise to 0 dB and then drop again to -3.00 dB. Press the Hz button to read the lower frequency limit of the bandwidth.

You can use a similar technique to examine the performance characteristics of frequency-sensitive filters, such as high or low-pass filters, notch filters, etc. With the 4½ digit frequency resolution and the 0.01 dB resolution, you can very accurately determine the rolloff, slope, and bandpass.

3-3. Using the 8060A as a Q-Meter

You can use the 8060A to determine the Q factor of a tuned circuit (refer to Figure 3-2). First use the technique presented in section 3-2 to determine the center frequency (fc) and bandwidth of the circuit (for tuned circuits, the center frequency of the bandwidth is found at the peak or midway within the high plateau of the dB readings). Then calculate the Q of the circuit by using the following formula:

$$Q = fc/Bandwidth$$

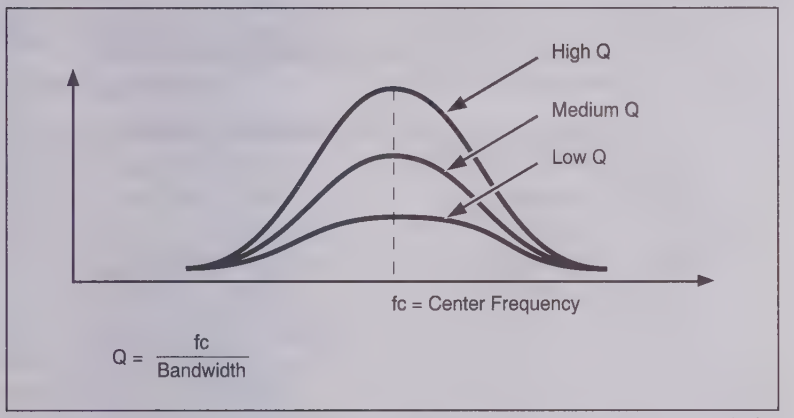

Figure 3-2. Measuring Q with the 8060A

3-4. Measuring Amplifier Stage Gain with Relative dB

When testing multi-stage amplifiers, we are usually interested in the dB gain or loss at each stage referenced to an initial dB level. Figure 3-3 shows an example of this kind of application with the 8060A. A 20 mV signal is applied to the first stage of a three-stage amplifier. This signal is measured with the 8060A in the ac voltage function. Then the dB button is pressed followed by the REL button which creates the relative reference 0 dB point. Each stage is then measured, and the 8060A displays the dB level with reference to the initial input.

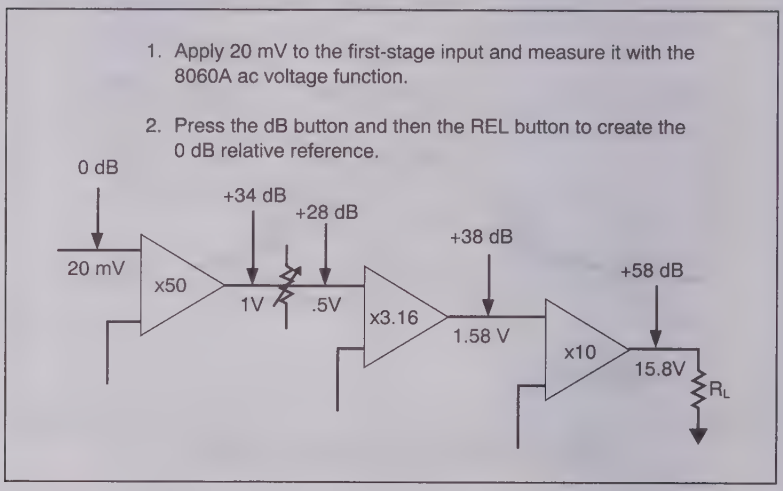

Figure 3-3. Measuring Stage Gain with Relative dB

3-5. General Audio Uses

You can perform many audio equipment tests using the 8060A with a minimum of other equipment. For example, connect the 8060A to the tape recorder output sockets of a phono amplifier with a shielded lead. Select the ac voltage dB function and the 200 mV range. Then play a frequency response test record (they are available at some of the larger audio equipment stores). You can establish a reference level by pressing the REL button while a particular frequency is being played. The signal level of all the other frequencies on the disc will be displayed in dB with reference to the original reference level. If you connect the 8060A to the speaker sockets of an audio amplifier and play the frequency response test record, you can adjust the filters and tone controls and check their performance.

The 8060A is also useful for a variety of maintenance tasks when servicing tape decks. Some of these tasks include setting up record and playback levels during calibration, head alignment, checking attenuator pads, and testing equalizers. Refer to manufacturer information for procedures.

3-6. Using the 8060A to Measure Extremely Low Currents

By using high impedance dc voltage function and high MΩ precision resistors, you can use the 8060A to measure extremely low currents. For example, if you place a 100 MΩ resistor across the 8060A and select the high impedance dc voltage function and the 200 mV range, the 8060A will measure a 2 nanoamp (10^{-9}A) current with 0.1 picoamp (10^{-12}A) resolution.

The error sources with this method of measurement are the combined accuracy specifications for the voltage range and the resistor, as well as the 8060A input bias current. The input bias current is typically 10 picoamps. You can measure the input bias current error by removing the test leads and selecting the normal dc voltage function and the 200 mV range. The number of digits in the display reading indicates the input bias current in picoamps (disregard the decimal point). You can correct for the input bias current by using the relative reference to zero the offset.

The best measurement results will be obtained at ordinary room temperature with low relative humidity. Be sure to use adequate shielding to prevent power line or rf interference.

3-7. Making dBm or dBW Measurements with Other Reference Impedances

The standard power-on reference impedance for 8060A dBm (decibels above or below one milliwatt) measurements is 600Ω, which is the most common reference impedance used in the data communications and audio fields. However, occasionally you might want to make measurements with a different reference impedance. For instance, the standard rf dBm reference impedance is 50Ω. Audio power amplifiers use dBW (decibels above or below one watt) referenced to 2, 4, 8, or 16Ω. The standard method for making these dBm or dBW measurements is to add or subtract a correction factor. With the 8060A, however, you can set up any of these reference impedances with the relative (REL) function.

To change the reference impedance, select the desired dB function and appropriate range, apply the equivalent voltage level obtained from Table 3-1 (or from the formulas at the bottom of Table 3-1), and press the REL button. The 8060A will store the equivalent voltage level, and subsequent dB measurements will be referenced to the new impedance.

For an example of how to use this feature, let's assume that you want to make ac voltage dBm measurements referenced to 50Ω. First select the 8060A ac voltage dB function and the 2V range. Referring to Table 3-1, we find that the equivalent voltage level for 0 dBm for 50Ω is 0.2236V and the equivalent dB level for 0 dBm referenced to 600Ω is -10.79 dBm. Apply an ac voltage to the 8060A input (VΩS and COMMON) and adjust the applied voltage level until the 8060A displays -10.79. Now press the REL button. The display should read 0.00 (with the dB and REL indicators at the top of the display). Measurements taken with the ac voltage dB function will now read dBm referenced to 50Ω.

Table 3-1. Equivalent Voltage Levels for Modifying the Reference Impedance

Reference Impedance Z (Ω)	Equiv. Voltage Level		Equiv. dB Level for 0 dBm REF. to 600Ω as Shown on the 8060A Display (dBm)
50		0.2236	-10.79
75		0.2739	-9.03
90		0.3000	-8.23
125	For	0.3536	-6.81
150	0 dBm (V)	0.3873	-6.02
300		0.5477	-3.01
600 (power-on value)		0.7746	0.00
900		0.9487	1.76
1000 (dBV)		1.0000	2.22
2		1.4142	5.23
4	For	2.000	8.24
8	0 dBm (V)	2.828	11.26
16		4.000	14.26

Use the following formulas to calculate equivalent voltage levels for reference impedances not listed.

For dBm: 0 dBm level (V) = $\sqrt{.001 \times \text{desired ref. impedance } (\Omega)}$

600Ω Ref. Equiv. (dBm) = 20 log [0 dBm level (V)/.7746]

For dBw: 0 dBw level (V) = $\sqrt{\text{desired ref. impedance } (\Omega)}$

600Ω Ref. Equiv. (dBm) = 20 log [0 dBm level (V)/.7746]

Whenever you use Table 3-1, be sure you start with the 600Ω reference impedance selected on the 8060A. Otherwise the values and formulas listed in Table 3-1 will be incorrect because they use the 600Ω reference impedance as a starting point.

After a reference impedance is stored with the REL button, the reference impedance will remain stored until the instrument is turned off or until another relative value is stored. You can cancel the stored reference by pressing the REL button, in which case the REL indicator will disappear and the reference impedance will revert to the power-on value, 600Ω. You can use other functions without losing a stored reference impedance as long as you do not store some other relative value.

3-8. Changing AC dB Reference Impedances with a DC Source

The most straightforward method of changing the reference impedance is to select the desired voltage dB function, apply the equivalent voltage, and press the REL button. However, a precision ac voltage source is not always as readily available as a dc voltage source. There is a method for using a variable 0 to 200 mV dc voltage source to set up virtually any reference impedance for ac voltage dB.

To use this method, place the AC/DC switch in the AC position and place the other two function switches in the out position. Find the equivalent dB level in Table 3-1 and select the appropriate range. Press the dB button. Beginning with a 200 mV input signal, slowly decrease the input signal until the proper dB level is displayed on the 8060A. Then press the REL button. Now you can select the ac voltage dB function and subsequent measurements will be referenced to the modified reference impedance.

Note that in this mode the input signal does not go through the voltage divider or the ac rms converter, but is applied directly to the a/d converter. Since the a/d converter inputs are between 0 and 200 mV for all ac ranges, the voltage you apply will always be between 0 and 200 mV, regardless of the range. For example, let's assume you want to use this method to establish a reference impedance of 90Ω. From Table 3-1 you can see this requires an input of 0.3000V. So you select the 2V range, but you only apply 30 mV dc of signal in the 2V range to make the reading appear to be 300 mV ac. Similarly, 30 mV dc of signal in the 20 V range will appear to be 3V ac, and in the 200V range will appear to be 30V ac.

Chapter 4
Theory of Operation

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4-1. Introduction

This chapter describes how the 8060A works. An overview of the operation is provided first, followed by descriptions of the two major components and the measurement functions. A detailed schematic of the instrument appears in Chapter 8.

4-2. Functional Description

The major circuits and components of the 8060A are arranged in a block diagram in Figure 4-1. Two major components make up the measurement system: a four-bit CMOS microcomputer, and a CMOS integrated circuit known as the Measurement Acquisition Chip (MAC). The microcomputer selects the appropriate measurement function in the MAC according to the switches or buttons pushed by the operator. The microcomputer also controls the measurement cycles, performs calculations on measured data, and drives the display. The MAC measures the conditioned input signals with the a/d converter or the frequency counter. The MAC also controls the power supply and the continuity tone generator. The microcomputer and the MAC communicate through a four-bit bidirectional bus and four control lines. Both components are described in more detail later in this chapter.

As shown in Figure 4-1, the input signals are routed by the range and function switches through the appropriate signal conditioners for input filtering and scale changes. Input signals for all measurement functions except frequency are converted to a proportional dc analog voltage that is applied to the a/d converter. The dual-slope a/d converter converts the dc analog voltage to a digital number that is sent to the microcomputer. Input signals for frequency measurement are ac voltages that are buffered by the ac converter and applied to the frequency counter in the MAC. The frequency counter supplies the digital number to the microcomputer. Each of the major measurement functions are described later in this chapter.

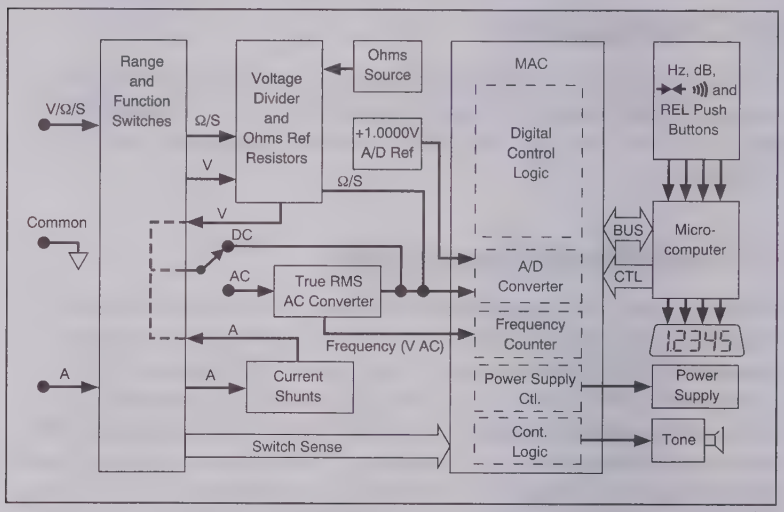

Figure 4-1. 8060A Block Diagram

4-3. Microcomputer

The four-bit CMOS microcomputer senses switch positions by reading status registers in the MAC, and senses button pushes through input lines connected directly to the microcomputer. The microcomputer processes the information and then selects the appropriate digital and analog configuration in the MAC by writing to an array of MAC control registers.

The operation of the instrument is controlled by software routines that are stored in the microcomputer memory. These routines include the normal operating routine, the power-on self-test, or special self-test routines that may be selected by the operator. When the instrument is first turned on, the microcomputer performs the self-test routine which checks the LCD segments and the interface to the MAC (refer to Chapter 2 for operating instructions). While the LCD segments are on (a minimum of 1.6 seconds), the microcomputer exercises the bus and checks the internal registers in the MAC to make sure it has control over them. If the microcomputer detects a problem with the MAC interface, it stays in the self-test routine with the LCD segments on until the problem is resolved or the instrument is turned off.

After the power-on self-test routine is successfully completed, the microcomputer checks to see if the operator has selected the ratio self-test or the switch decoding self-test (refer to Chapter 5 for operating instructions). If neither of the self-tests has been selected, the microcomputer begins the normal operating routine. The operating routine consists of four steps:

1. The microcomputer reads the function and range selections and checks the four push buttons to determine the mode the operator has selected. The microcomputer then selects either the a/d converter (for measurement of voltage, current, resistance, conductance, continuity, or the diode test) or the frequency counter.
2. The microcomputer initiates either the a/d measurement cycle (approximately 400 ms) or the frequency measurement cycle (approximately 1.0s). The measurement cycles are described later in this chapter.
3. The microcomputer processes the data obtained in the measurement cycle. This includes calculations for the dB, relative (REL) offset, and MΩ or frequency autoranging.
4. The microcomputer displays the results. The results remain on the display until it is updated.

After the results are displayed, the routine begins again at the first step.

4-4. Measurement Acquisition Chip (MAC)

A block diagram of the MAC is shown in Figure 4-1. The digital control logic includes a buffer and decoder, read and write logic, status and control registers, and logic control for the continuity function. The power supply control uses the calibrated 1V a/d reference voltage obtained from a bandgap reference diode to regulate the 5.2V main power supply for the instrument. When the continuity function is selected and continuity is detected, the MAC generates the tone by supplying a square wave to the external piezoelectic transducer.

4-5. A/D Conversion Cycle

The heart of the MAC is the dual-slope a/d converter. A block diagram of the analog portion of the a/d converter is shown in Figure 4-2. The internal buffer, integrator, and comparators work in conjunction with external resistors and capacitors to convert the dc analog voltage to a digital number. The internal switches are FET switches that are controlled by the microcomputer and the MAC digital control logic. The switchable integrator gain depends on the function and range selected.

The complete a/d measurement cycle is shown in Figure 4-3. It consists of three consecutive time periods: autozero (AZ), integrate (INTEG) and read. A fourth time period, overload (OL) is also used if an overrange reading is taken. The total length of the measurement cycle is 400 ms. The length of the integrate period is fixed at 100 ms. One hundred ms is a multiple of the period of 50 Hz or 60 Hz power, which helps to reduce possible power line noise that might interfere with the measurement. The waveform at the INTEG capacitor is shown for three sample measurement readings: half-scale, full-scale, and overrange.

The measurement cycle begins with the autozero period. The AZ switches close, applying a ground reference as the input to the converter. Under ideal conditions the output of the comparator would also go to zero. However, input-offset voltage errors accumulate in the buffer amplifier loop, and appear at the comparator output as an error voltage. To compensate for this error, the error is impressed across the AZ capacitor where it is stored for the remainder of the measurement cycle. The stored level is used to provide offset voltage correction during the integrate and read periods.

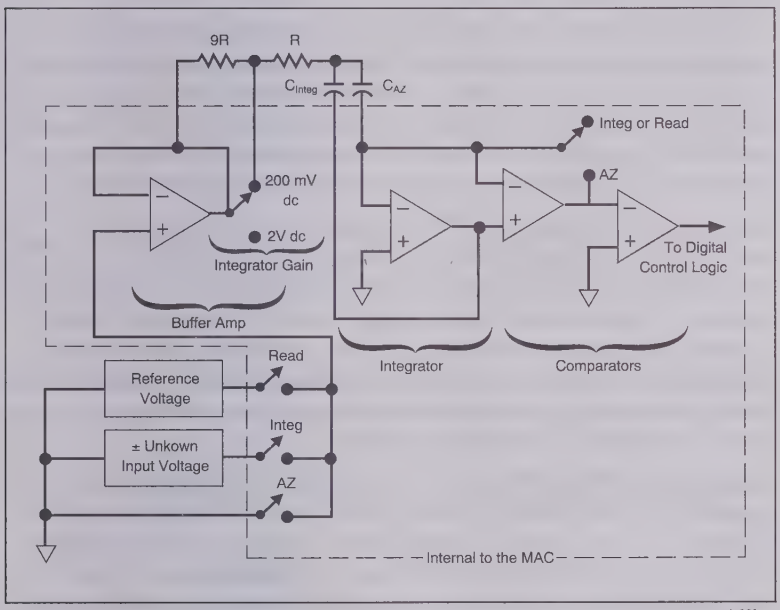

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Figure 4-2. Analog Portion of the A/D Converter

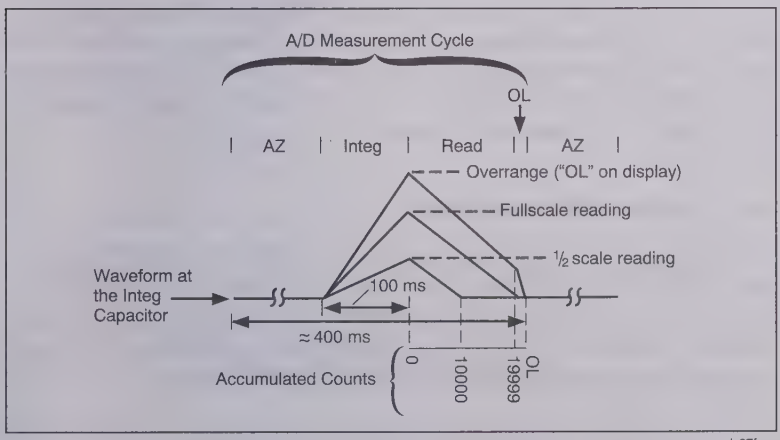

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Figure 4-3. A/D Measurement Cycle

The integrate period begins at the end of the autozero period. As the period begins, the AZ switches open and the INTEG switches close. This applies the unknown input voltage to the input of the converter. The voltage is buffered and then begins charging the INTEG capacitor. The waveform at the INTEG capacitor is a ramp from near zero to some maximum value determined by the amplitude and polarity of the unknown input voltage.

As the read period begins, the INTEG switches opens and the READ switches close. This applies the known reference voltage from a "flying" capacitor whose polarity is chosen by the a/d converter to be the opposite of the polarity of the unknown input voltage. The INTEG capacitor begins discharging at a fixed rate while a counter begins counting. The counter stops counting when the INTEG capacitor voltage equals the initial autozero voltage. The count is proportional to the unknown input voltage, and is placed on the display by the microcomputer.

If during the read period the counter counts up to the maximum number of counts for a full-scale reading (19999 counts) and the INTEG capacitor charge has not yet reached the initial autozero voltage, the microcomputer knows an overrange reading has been taken. The microcomputer places "OL" on the display and commands the a/d converter to go into the overload (OL) period which rapidly slews the integrator voltage back to the initial autozero voltage.

The measurement cycle ends at the end of the read period for an on-scale reading, or at the end of the overload period for an overrange reading. A new measurement cycle then begins with the autozero period. The display update rate for measurement functions that use the a/d converter is approximately 0.4s, or about 2-1/2 readings per second.

4-6. Voltage Measurement

Both the ac and dc voltage ranges use an over-voltage protected 10 MΩ input divider as shown in Figure 4-4. The over-voltage protection includes two 2-watt fusible resistors and four metal-oxide varistors for high voltage clamping. Depending on the range selected, lower leg resistors of the divider are connected to ground to perform the input signal division.

The dc input voltages for all ranges are divided by the appropriate factor of 10 to produce a proportional dc signal which is then filtered and applied to the input to the a/d converter. The dc and ac voltage ranges and division factors are listed in Table 4-1 along with the corresponding range of inputs to the a/d converter. Notice in Table 4-1 that the 2V dc voltage range is divided by 1 (not 10). The microcomputer compensates by decreasing the integrator gain in the a/d converter by a factor of 10 (refer to Figure 4-2). The integrator gain is also reduced by a factor of 10 in the 1000V dc voltage range, which uses the same divider arrangement as the 200V dc voltage range.

The ac input voltages are divided with the same divider arrangement as the dc input voltages, with the exception that the 2V ac voltage range is divided by 10. The divider output signals for ac voltages are ac-coupled to the input of a true rms ac converter which produces a current output. This negative dc representation is applied through a calibrated scaling resistor. The resultant negative voltage is filtered and applied to the input of the a/d converter.

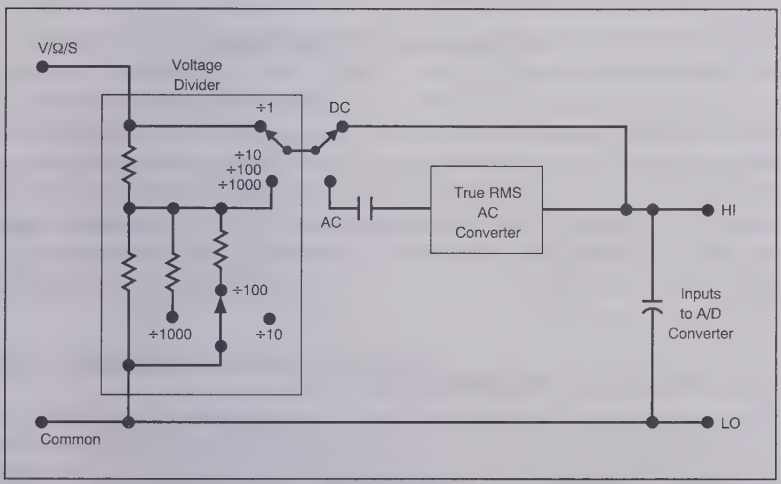

Figure 4-4. Voltage Measurement

Table 4-1. Voltage Input Divider

Function	Range	Input Divider	Range of A/D Converter Input
DC Voltage	200 mV	1/1	-200 mV to +200 mV
	2V*	1/1	-2V to + 2V
	20V	1/100	-200 mV to + 200 mV
	200V	1/1000	-200 mV to + 200 mV
	1000V*	1/1000	-2V to + 2V (1V max. input)
AC Voltage	200 mV	1/1	0 to -200 mV
	2V	1/10	0 to -200 mV
	20V	1/100	0 to -200 mV
	200V	1/1000	0 to -200 mV
	1000V*	1/1000	0 to -2V (-0.75V max. input)
*Integrator gain in a/d converter reduced by factor of 10.			

4-7. Current Measurement

Current measurements are made using a double-fuse-protected, switchable, five-terminal current shunt (0.1 ohm, 1 ohm, 10 ohm, 100 ohm, or 1 kilohm) to perform the current-to-voltage conversion required by the a/d converter. A block diagram of current measurements is shown in Figure 4-5. When the dc current function is selected, the dc voltage drop across the shunt is filtered and applied to the input of the a/d converter. When the ac current function is selected the ac voltage drop across the shunt is ac-coupled to the input of the true rms ac converter. The dc representation of the ac voltage is filtered and applied to the input of the a/d converter. All current ranges use the ±200 mV a/d converter input range.

4-8. Resistance Measurement

Resistance measurements are made using a ratio technique as shown in Figure 4-6. When the resistance function is selected, a series circuit is formed by the ohms source, a reference resistor for the voltage divider (selected by the range switches), and the external unknown resistor. The ratio of the two resistors is equal to the ratio of the voltage drop across each of them. Since the voltage drop across the reference resistor and the value of the reference resistor are known, the value of the second resistor can be determined. Input protection during resistance measurements consists of a thermistor and a double-transistor clamp.

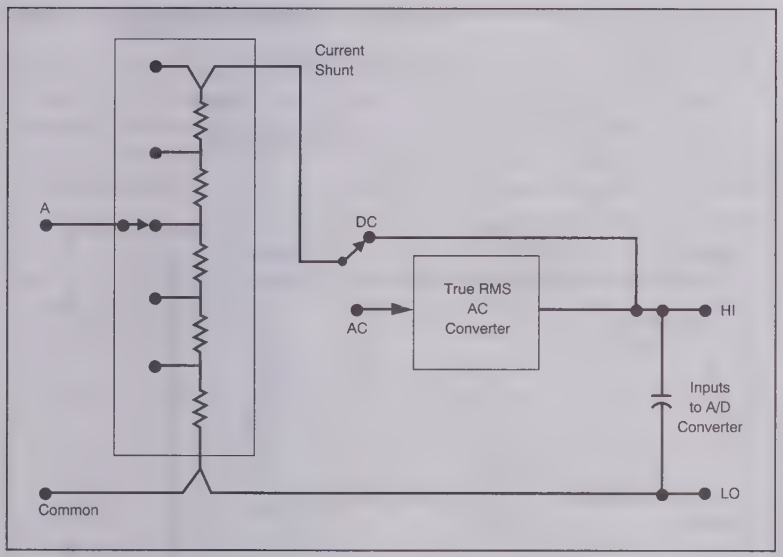

Figure 4-5. Current Measurement

The operation of the a/d converter during a resistance measurement is basically as described earlier in this chapter, with a few exceptions. During the integrate period the voltage drop across the unknown resistor charges the INTEG capacitor. During the read period, the voltage across the known resistor (stored on the flying capacitor) discharges the INTEG capacitor. The length of the read period is a direct indication of the value of the unknown resistor.

4-9. Conductance Measurement

Conductance measurements are made using a ratio technique similar to that used in making resistance measurements as shown in Figure 4-6. The main difference is that the function of the range and unknown resistors in the a/d measurement cycle is reversed so that the smaller voltage is applied during the integrate period, which minimizes error due to noise. During the integrate period the voltage drop across the known resistor charges the INTEG capacitor. During the read period the voltage drop across the unknown resistor discharges the capacitor. Consequently the display presents a reading that is the reciprocal of resistance, which is conductance.

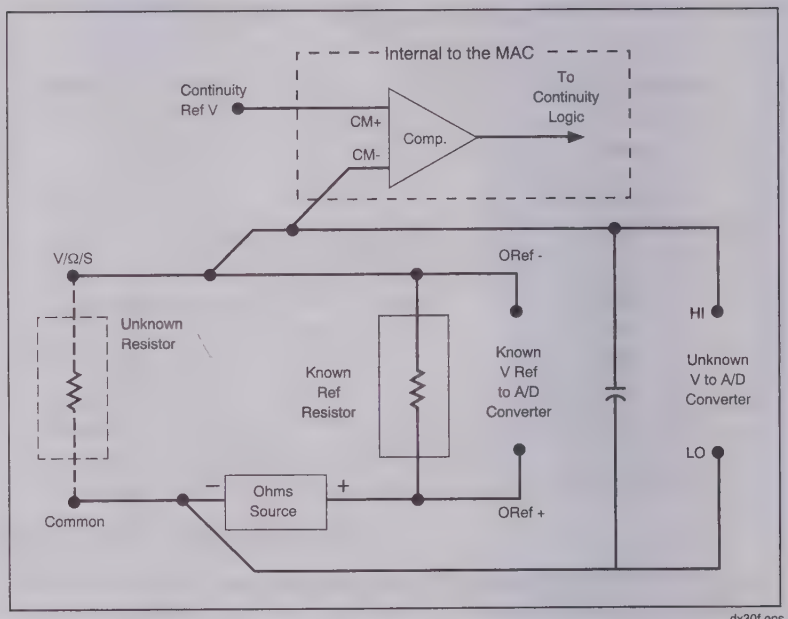

Figure 4-6. Resistance/Conductance/Continuity Measurement

4-10. Continuity Measurement

Continuity measurement is a voltage comparison made in the resistance mode as illustrated in Figure 4-6. The 8060A determines whether continuity exists in the circuit under test by comparing the voltage drop across the external circuit with a continuity reference voltage. If the voltage drop across the external circuit is less than the reference voltage, the comparator sends the appropriate signal to the continuity logic. The continuity logic notifies the microcomputer which turns on the visible indicator (the full-length bar across the top of the display). If the audible indicator is enabled, the continuity logic enables the tone generator.

The detection threshold is typically 10% of the full scale resistance range selected. When the 8060A detects continuity for brief intervals (50 μs or greater), the microcomputer extends the visible and audible indication to a minimum of 200 ms to allow easy perception by the operator.

4-11. Frequency Measurement

Frequency measurement is illustrated in Figure 4-7. The ac input signal is divided by the voltage divider (Figure 4-4) and buffered by the ac rms converter. The signal is then applied to a comparator in the MAC for counting. The counter gate is controlled by the microcomputer, and the range is automatically selected by the software in the microcomputer. For very low frequency input signals, the counter actually measures the period of the input signal which the microcomputer then inverts to derive the corresponding frequency. The display update rate for all ranges is approximately one second (except for frequencies between 12.2 and 16 Hz, which are updated every 1 to 1.3s).

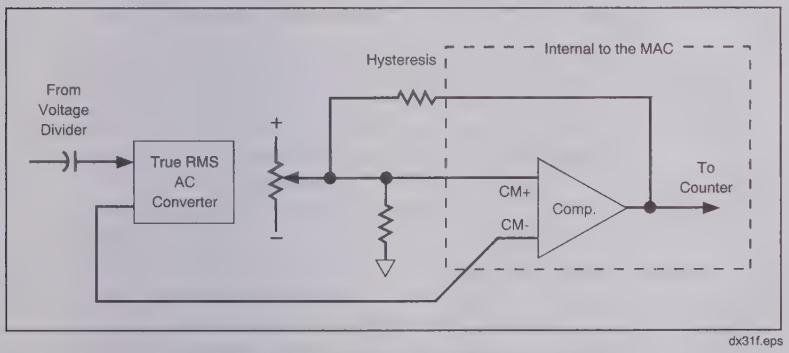

Figure 4-7. Frequency Measurement

Chapter 5
Maintenance

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5-1. Introduction

⚠ Warning

These servicing instructions are for use by qualified personnel only. To avoid electric shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

This chapter of the manual contains information regarding the maintenance of your instrument. It includes information about disassembly, performance tests, calibration adjustments, and troubleshooting. The combined performance tests are recommended as an acceptance test when the instrument is first received, and can be used later as preventive maintenance tool.

A one-year calibration cycle is recommended to maintain the specifications given in Chapter 1 of this manual. The test equipment required for the performance tests or calibration adjustments is listed in Table 5-1. Test equipment with equivalent specifications may also be used.

5-2. Service Information

The 8060A is warranted for a period of one year upon shipment of the instrument to the original purchaser. Conditions of the warranty are given at the front of this manual. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the purchaser. For in-warranty repair, call (toll-free) 800 426-0361 for the address of the nearest Fluke Technical Service Center designated to service your instrument. (In Alaska, Hawaii, Washington or Canada call 206 356-5400.) Ship the instrument postpaid in the original shipping container (if available). Dated proof-of-purchase may be required for in-warranty repairs.

Fluke Technical Service Centers are also available for calibration and/or repair of instruments that are beyond the warranty period. Call the number listed above for shipping information. Ship the instrument and remittance in accordance with instructions received.

Table 5-1. Required Test Equipment

Equipment	Required specifications	Recommended Type
DMM Calibrator	DC Voltage: 0 to 1000V, ±(0.0075%) AC Voltage: 200 Hz to 1 kHz, 0 to 750V, ±(0.06%) 1 kHz to 10 kHz, 0 to 200 V, ±(0.06%) 10 kHz to 30 kHz, 0 to 200V, ±(0.1%) 30 kHz to 50 kHz, 0 to 200V, ±(0.25%) 50 kHz to 100 kHz, 0 to 2.0V, ±(0.75%) Resistance: 100Ω to 10.0 MΩ, ±(0.1%)	Fluke 5100B with Options Y5000, 5100A-03, and Fluke 5205A Amplifier
	DC Current: 0 to 2000 mA, ±(0.05%) AC Current: 20 Hz to 3 kHz, 0 to 2000 mA, ±(0.25%)	Fluke 5100B with Option Y5000 and Fluke 5220A Amplifier
Reference Resistors	40 MΩ and 290 MΩ, ±(0.1%)	Caddock MG750*
Signal Source	Frequency: 25 mV to 200 mV, 100 Hz to 200 kHz, ±(0.1%)	Fluke 5700A
DMM	DC Voltage: 200 mV to 20V, ±(0.25%) DC Current: 2 mA to 200 mA, ±(0.1%)	Fluke 87
*Precision high MΩ resistors may be ordered from Caddock Electronics, 3127 Chicago Ave., Riverside, CA, 92507. Be sure to specify 0.1% tolerance.		

5-3. General Information

It is recommended that you periodically check the battery and perform the performance tests (paragraphs 5-11 through 5-20).

5-4. Handling Precautions for Using Static Sensitive Devices

Caution

This instrument contains CMOS components which can be damaged by static discharge. Static sensitive components on the main pcb include U3 and U4. The microcomputer pcb includes one static sensitive component, U5, the microcomputer. To prevent damage, take the following precautions when troubleshooting and/or repairing the instrument:

- Perform all work at a static-free work station.
- Do not handle components or pcb assemblies by their connectors.
- Wear static ground straps.
- Use conductive foam to store components.
- Remove all plastic, vinyl and styrofoam from the work area.
- Use a grounded, temperature-regulated soldering iron.

5-5. Disassembly and Reassembly

The instrument has two pcbs: the main pcb and the microcomputer pcb. To gain access to the calibration adjustments, the backup fuse, or the LCD, you have to remove only the top cover. You can also do some troubleshooting with only the top cover and the top ac shield off. For other troubleshooting or to gain access to the microcomputer pcb, you have to remove the main pcb from the case. If you remove the main pcb from the case, you will need to perform the calibration adjustments. Be sure to heed the notes and cautions about special handling requirements.

Note

It is not necessary to remove the main pcb from the bottom case in order to disassemble or reassemble the LCD. However, because the LCD and the microcomputer require similar special handling, the disassembly and reassembly procedures are described together.

Caution

To avoid contaminating the pcbs with oil from the fingers, handle the pcbs by the edges or wear gloves.

5-6. Calibration and Backup Fuse Access

Use the following procedure to gain access to the calibration adjustments or the backup fuse (F2):

1. Disconnect the test leads and battery eliminator, if attached. Turn the power switch off.
2. Remove the three phillips screws from the bottom of the case.
3. Turn the instrument face-up and grasp the top cover at both sides of the input connectors. Then pull the top cover from the unit. The backup fuse and the calibration adjustments are now accessible (Figure 5-1).

Caution

The function buttons below the display are part of a single elastomeric strip (Figure 5-1) that is held in place by the top cover. When the top cover is removed, the elastomeric strip will be loose and may be removed. Do not touch or contaminate the carbon-impregnated switch contacts on the bottom of the strip or the switch contacts on the display pcb. If the contacts do become contaminated, clean them with isopropyl alcohol.

4. To reassemble, position the elastomeric strip on the microcomputer pcb so that the small rubber posts on the bottom of the strip are properly seated. Install the top cover and fasten the three screws on the bottom case.

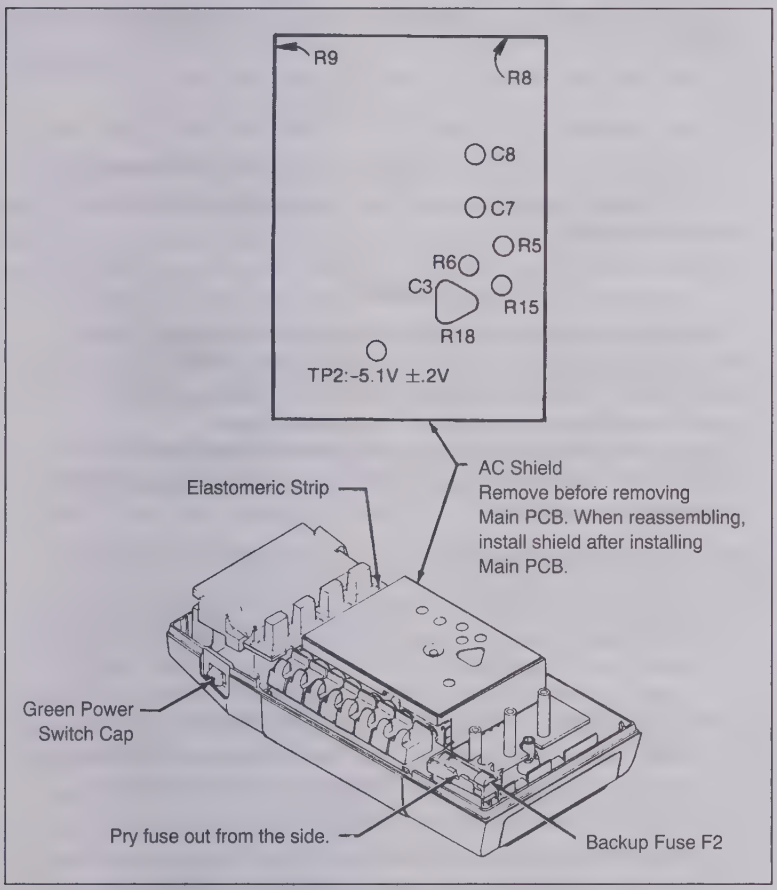

Figure 5-1. Calibration and Backup Fuse (F2) Access)

5-7. Main PCB Access

Use the following procedure to gain access to the main pcb:

1. Remove the screw in the center of the ac shield and remove the shield.
2. Using your index finger, lift up the lower right corner of the main pcb until it is free. Then pull the pcb to the right until it clears the shelf under the buttons.

Caution

Do not touch or contaminate the plastic insulator that is attached to the inside of the case bottom. When the instrument is assembled the insulator makes contact with the leads on the bottom of the main pcb. Contaminants could cause undesirable conduction paths. If the insulator becomes contaminated, clean with isopropyl alcohol.

3. Reassemble in the logical reverse order and heed the following notes:
   a. When reassembling, be sure to put on the ac shield after the main pcb has been placed in the case bottom. The reason for this is that the screw which holds down the ac shield has a spring attached. The spring provides the electrical connection between the top of the ac shield and the bottom of the shield (under the insulator). If the ac shield is attached to the main pcb before the main pcb is in the case, the spring may fold across the insulator and not be in proper position to make the electrical connection.
   b. Be sure to place the green power switch cap over the small black power switch before sliding the main pcb into the case.
   c. Be sure to route the battery-clip wires to the left side of the post under the backup fuse case.

5-8. LCD and Microcomputer PCB Disassembly and Assembly

Note

This procedure applies to serial number 3995000 and higher.

The procedure for disassembling or assembling the LCD and the microcomputer pcb is not difficult, but the steps must be followed in sequence. Before you try the procedure, examine the components in Figure 5-2 and familiarize yourself with the following handling precautions:

- The microcomputer, U5 (item 4 in Figure 5-2), is a static sensitive CMOS device. Follow the standard procedures for handling static sensitive devices.
- The LCD interconnect (item 7) and the microcomputer interconnect (item 5) should not be touched with fingers or contaminated. Handle these items with tweezers and keep them clean.
- The microcomputer interconnect (item 5) is susceptible to corrosion caused by the reaction between the metal in the connector and possible contaminates in the air such as smoke or sulfur. Store the connector in an air-tight container if the LCD is disassembled for a long period of time.
- Do not get fingerprints or dirt on the LCD display, the display lens, or the gasket.
- While the LCD and microcomputer pcb are assembled, take care not to press down on the display lens because pressure could damage the LCD.

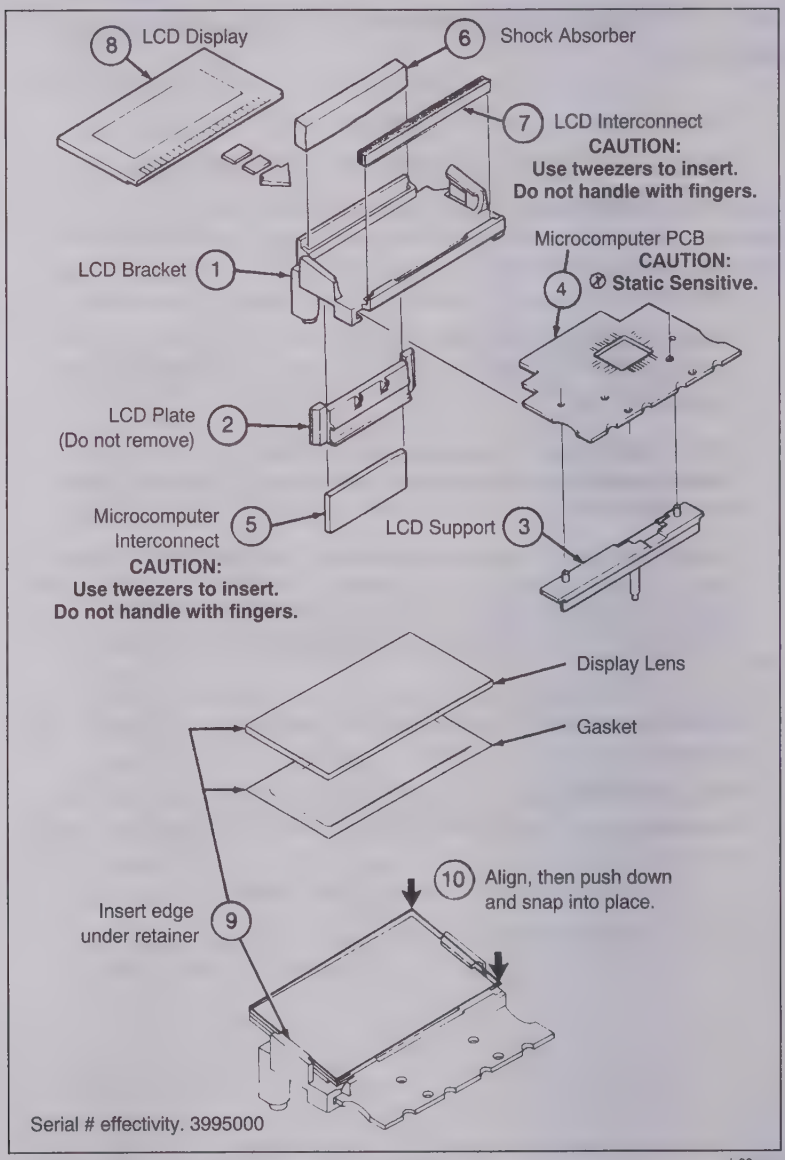

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Figure 5-2. Assembling/Disassembling the Microcomputer PCB and LCD

To disassemble the LCD, use your thumbnails and push on the corners of the LCD display, gasket and display lens so that all three components slide out together as shown in Figure 5-3.

Note

It is not necessary to remove the main pcb from the button case to disassemble or reassemble the LCD.

To assemble the LCD, use the following procedure:

1. Align the LCD display (item 8) as indicated in Figure 5-2 and slide it into place. The bottom edge of the LCD display should compress the LCD interconnect (item 7) and slide underneath the two plastic notches on the LCD bracket (item 1).
2. Refer to Figure 5-2 and follow steps 9 and 10 to complete assembly.

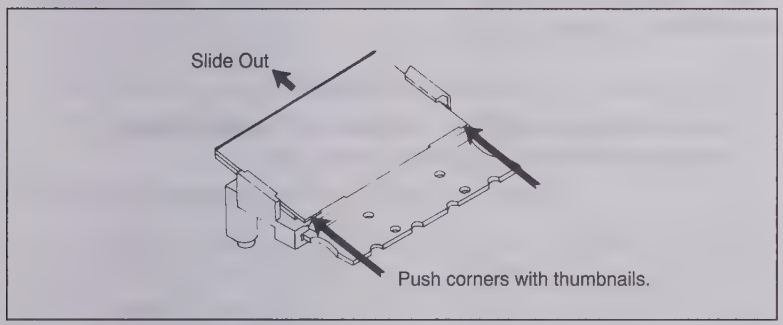

Figure 5-3. Disassembling the LCD

To disassemble the microcomputer pcb, use the following procedure:

1. Turn the main pcb face down and remove the two small screws at the top of the pcb to free the microcomputer pcb.
2. Refer to Figure 5-2. Beginning with item 7, remove items 7 through 3 (leave item 2 attached to item 1). Be sure to observe the handling precautions for items 7, 5, and 4.

To assemble the microcomputer LCD, refer to Figure 5-2. Beginning with item 3, assemble items 3 through 7 (in ascending numerical order). Be sure to follow the handling precautions for items 4, 5, and 7.

5-9. Backup Fuse Replacement

Use the following procedure to replace the backup fuse (F2):

1. Remove the top cover by following the precautions given previously for the calibration and backup fuse access.
2. Use a flat-tipped screwdriver to pry the fuse out of its fuse holder. Pry the fuse from the side as indicated in Figure 5-1.
3. Replace the defective backup fuse with a 3A/600V type BBS-3 (Fluke PN 475004). Refer to section 2-4 for information about replacing fuse F1 (2A/250V; American style: fast acting type AGX2, 1/4 x 1", Fluke PN 376582.; European style: 5 x 20 mm, Fluke PN 460972).

5-10. Cleaning

Clean the front panel and case with a damp cloth and mild detergent. Do not use abrasives, solvents, or alcohol.

⚠ Warning

To avoid electrical shock, remove test leads and any input signals before cleaning operation.

5-11. Performance Tests

The following procedures allow you to compare the performance of your instrument with the specifications listed in Chapter 1. They are recommended for incoming inspection, periodic calibration, and to verify specifications. If the instrument fails any test, calibration adjustment and/or repair is needed. You do not have to disassemble the instrument to perform the tests. Throughout these procedures, the 8060A being tested is referred to as the UUT (Unit Under Test).

5-12. Initial Procedure

For any of these tests, make sure you do the following:

1. Allow the temperature of the UUT to stabilize in a test environment with an ambient temperature of 23 ±5°C (73 ±9°F) and a relative humidity of less the 80%.
2. Check the fuses and battery and replace them, if necessary.
3. Make sure the leads are disconnected from the UUT. Set the power switch to on and set all other switches to the out (off) position.

5-13. Microcomputer and Display Test

Use the automatic power-on self-test to test the microcomputer and the LCD display. Turn the UUT off, then turn it on while observing the display. All of the LCD segments should turn on. After about one or two seconds, the display should go blank briefly and then respond to switch selections.

5-14. Voltage Test

Use the following procedure to verify proper operation of the dc voltage, ac voltage, and dB functions.

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.
2. For each step in Table 5-2, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

Table 5-2. Voltage Test

Step	Function	Range	Input Signal		Display Limits
			Level	Freq.	
1	DC Voltage	200 mV	+ 190.00 mV	dc	189.91 to 190.09
2		200 mV	-190.00 mV		-189.91 to -190.09
3		2V	1.9000V		1.8991 to 1.9009
4		20V	19.000V		18.989 to 19.011
5		200V	190.00V		189.89 to 190.11
6		1000V	1000.0V		999.3 to 1000.7
7	AC Voltage	200 mV	100.00 mV rms	50 Hz*	99.67 to 100.33
8	AC Voltage		100.00 mV rms	10 kHz	99.60 to 100.40
9	AC dB	2V	1.9000V rms	50 Hz*	7.69 to 7.89 (dB)
10	AC Voltage	2V	1.0000V rms	50 Hz*	.9937 to 1.0063
11			1.0000V rms	1 kHz	.9937 to 1.0063
12			1.0000V rms	10 kHz	.9930 to 1.0070
13			1.0000V rms	30 kHz	.9860 to 1.0140
14			1.0000V rms	100 kHz	.9500 to 1.0500
15			1.0000V rms	20 Hz	.9890 to 1.0110
16			200.0 mV rms	50 Hz*	.1978 to .2022
17			200.0 mV rms	30 kHz	.1940 to .2060
18	AC Voltage	20V	10.000V rms	50 Hz*	9.937 to 10.063
19				10 kHz	9.930 to 10.070
20				30 kHz	9.860 to 10.140
21	AC Voltage	20V	10.000V rms	100 kHz	9.500 to 10.500
22		200V	100.00V rms	50 Hz*	99.37 to 100.63
23		200V	100.00V rms	10 kHz	99.30 to 100.70
24		200V	100.00V rms	30 kHz	98.60 to 101.40
25		200V	100.00V rms	100 kHz	95.00 to 105.00
26		1000V	750.0V rms	100 Hz	741.3 to 758.7
27		1000V	750.0V rms	1 kHz	741.3 to 758.7

* If power line frequency is 50 Hz use 60 Hz test frequency.

5-15. Resistance Test

Use the following procedure to verify proper operation of the resistance function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.
2. Select the resistance function and follow the steps 1 through 7 as listed in Table 5-3. For each step, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

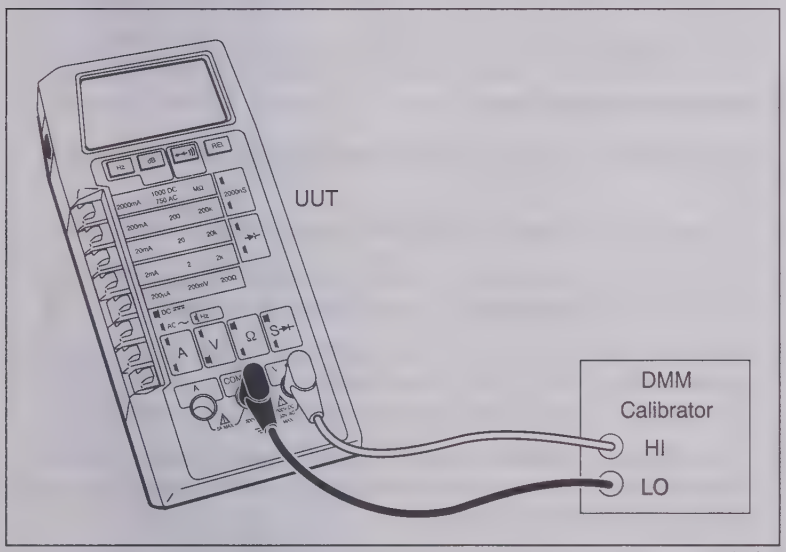

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Figure 5-4. General Equipment Connection

Note

Most DMM Calibrators do not test resistance values beyond 10 MΩ To test the resistance function beyond 10 MΩ (optional steps 8 and 9 in Table 5-3), disconnect the DMM Calibrator and connect a precision Reference Resistor for each value.

Table 5-3. Resistance Test

Step	Range	Input Resistance	Display Limits
1	200Ω	short circuit	0.00 to 0.04
2	200Ω	100.00Ω	99.89 to 100.11
3	2 kΩ	1.0000 kΩ	.9991 to 1.0009
4	20 kΩ	10.000 kΩ	9.991 to 10.009
5	200 kΩ	100.00 kΩ	99.91 to 100.09
6	MΩ	1.0000 MΩ	.9983 to 1.0017
7	MΩ	10.00 MΩ	9.95 to 10.05
8 (optional)	MΩ	40.0 MΩ	39.3 to 40.7
9 (optional)	MΩ	290 MΩ	282 to 298

5-16. Continuity Test

Use the following procedure to verify proper operation of the continuity function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.
2. Select the resistance function and the 2 kΩ range. Press the ➡◀))) button once. The ➡◀ symbol should appear on the display.
3. Apply a resistance of 100.0Ω. The long bar across the top of the display should appear on the display immediately. A reading of .0997 to .1003 should appear shortly thereafter (negating any test lead resistance).
4. Press the ➡◀))) button to enable the audible continuity (the 100.0Ω still applied). The))) symbol should appear on the display with the ➡◀ symbol. The tone should sound.
5. Remove the connections to the input of the UUT. The tone should stop and the bar should disappear from the display. The display should indicate OL (overrange) along with the ➡◀ and))) symbols.

5-17. Conductance Test

Use the following procedure to verify proper operation of the conductance function:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-4.
2. Select the conductance (S) function.

3. Apply a resistance of 1.000 MΩ. A reading of 993.0 to 1007.0 should appear on the display.
4. Remove the resistance from the inputs to the UUT. The display should read 0.0 to 0.2.

5-18. Current Test

Use the following procedures to verify proper operation of the dc and ac current functions:

1. Connect the UUT and the DMM Calibrator as shown in Figure 5-5.
2. For each step in Table 5-4, select the UUT function and range as indicated. Program the DMM Calibrator for the specified input signal and verify that the displayed UUT value is within the indicated limits.

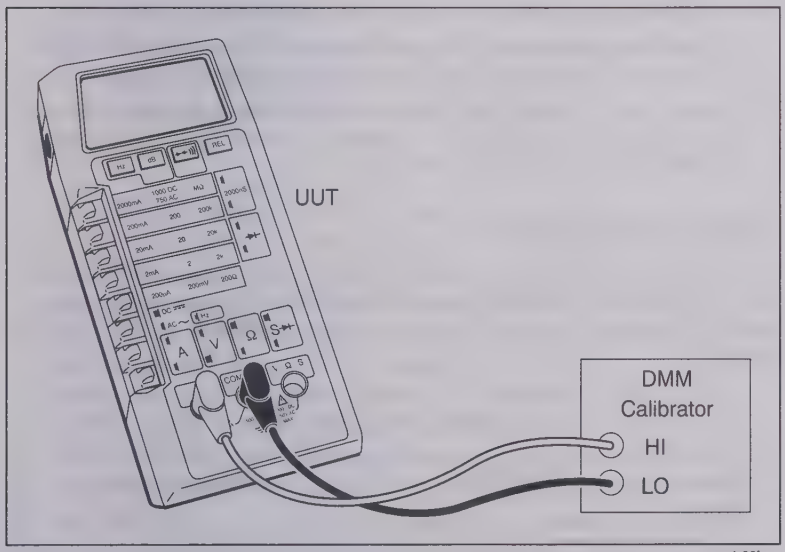

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Figure 5-5. Equipment Connection for Current Test

Table 5-4. Current Test

Step	Function	Range	Input Signal		Display Limits
			Level	Freq.	
1	Current dc	200 μA	190.00 μA	dc	189.60 to 190.40
2		200 μA	-190.00 μA		-189.60 to -190.40
3		2 mA	1.9000 mA		1.8960 to 1.9040
4		20 mA	19.000 mA		18.941 to 19.059
5		200 mA	190.00 mA		189.41 to 190.59
6		2000 mA	1900.0 mA		1894.1 to 1905.9
7		2000 mA	-1900.0 mA		-1894.1 to -1905.9
8	Current dc	20 mA rms	19.000 mA	1 kHz	18.848 to 19.152

5-19. Diode Test

Use the following procedure to verify proper operation of the diode test:

1. Remove any connections to the inputs of the UUT and select the diode test function. The display should indicate OL (overrange).
2. Connect the UUT and the DMM Calibrator as shown in Figure 5-4 and apply a resistance of 1.000 kΩ. a reading of .9000 to 1.1000 (typical) should appear on the UUT display.

5-20. Frequency Test

To verify the proper operation of the frequency function, connect the signal source to the V and COMMON inputs of the UUT. Select ac voltage and push the Hz button to select the frequency function. Follow the steps listed in Table 5-5.

Table 5-5. Frequency Test

AC Volts Range	Input Signal		Display Limits
	Level	Freq.	
200 mV	20.0 mV	100.00 Hz	99.94 to 100.06 ±3 counts*
200 mV	100.0 mV	190.00 kHz	189.91 to 190.09
2V	200.0 mV	19.000 kHz	18.991 to 19.009
*May be noisy due to low signal level.			

5-21. Calibration Adjustment

Under normal operating conditions the 8060A should maintain the specifications given in Chapter 1 of this manual for at least one year after calibration. If your 8060A has been repaired or if it has failed any of the performance tests, you need to perform the calibration adjustments.

Test equipment needed for the adjustments is listed in Table 5-1. If the test equipment is not available, your nearest Fluke Service Center will be glad to help. Call the number listed in section 5-2 of this manual for assistance. After you have completed the calibration adjustments, we recommend that you complete the performance tests to verify proper operation. In the following procedure, the 8060A that is being adjusted is referred to as the UUT (Unit Under Test).

Note

The top ac shield should remain installed on the instrument while the calibration adjustments are being performed. The positions of the trimpots and trimcaps are marked on the top ac shield along with a table summarizing the calibration procedures.

Note

The performance of the 8060A ac functions is affected by the capacitance between the main pcb and the bottom ac shield, which is dependent on the distance between them. The distance may vary, depending on whether the top cover is installed. To minimize performance variations, make certain the instrument is firmly seated in the bottom case before making any calibration adjustments. After you have performed the adjustments and installed the top cover, if you find that the measurement values obtained for the ac function performance tests are consistently too high or too low, remove the top cover and repeat the adjustments accordingly.

1. Allow the UUT to stabilize with the power off for at least 30 minutes at an ambient temperature of 21 to 25°C (70 to 77°F).
2. Complete the calibration access procedure presented earlier in this chapter.
3. Connect the equipment as shown in Figure 5-4 and turn on the equipment.

4. On the UUT, select the dc voltage function and the 2 volt range. Turn R6 fully clockwise (CW), and turn R5 fully counterclockwise (CCW).
5. Program the DMM Calibrator for an input of 1.9000V dc. Adjust R5 for a display reading slightly greater than 1.9000. Adjust R6 for a display reading between 1.8999 and 1.9001.
6. On the UUT, select the 200 mV range (dc voltage functions).
7. Program the DMM Calibrator for an input of 190.00 mV dc. Adjust R8 for a display reading between 189.99 and 190.01.
8. On the UUT, select the ac voltage function and the 200 mV range. Turn R18 fully CW, and turn R15 fully CCW.
9. Program the DMM Calibrator for an input of 100.00 mV ac at 200 Hz. Adjust R15 for a display reading slightly greater than 100.00. Adjust R18 for a display reading between 99.95 and 100.05.
10. On the UUT, select the 200V range (ac voltage function). Program the DMM Calibrator for an input of 100.00V ac at 10 kHz. Adjust C3 until the display reading is between 99.95 and 100.05.
11. On the UUT, select the 2V range (ac voltage function). Program the DMM Calibrator for an input of 1.0000V ac at 10 kHz. Adjust C7 until the display reading is between .9985 and 1.0015.
12. Repeat steps 10 and 11 before proceeding to step 13.
13. On the UUT, select the 20 V range (ac voltage function). Program the DMM Calibrator for an input of 10.000V ac at 10 kHz. Adjust C8 until the display reading is between 9.990 and 10.010.
14. On the UUT, select the 200 mV range (ac voltage function) and press the Hz button under the display. The Hz indicator should appear on the display.
15. Program the DMM Calibrator for an input of 50 mV ac at 100 kHz. Adjust R9 for a stable reading between 99.95 and 100.05.
16. Decrease the signal input by 5 mV and repeat step 15. If the signal level is no longer sufficient to obtain the required reading, leave R9 at the most stable and accurate setting.

5-22. Troubleshooting

Caution

Static discharge can damage MOS components U3, U4, and U5. Follow the handling precautions for static sensitive devices previously described in this chapter. Never remove, install or otherwise connect or disconnect components without first setting the instrument power switch off and disconnecting any inputs to the instrument.

If necessary, refer to Chapter 2 for operating instructions or Chapter 4 for the theory of operation. The troubleshooting information is supported by the schematics and tables in Chapter 8.

5-23. Self-Tests

The 8060A offers three self-tests: power-on self-test, ratio self-test, and switch decoding self-test. The power-on self-test is automatically performed whenever the instrument is turned on. It is described in Chapters 2 and 4. The other two tests function as follows:

5-24. Ratio Self-Test

The ratio self-test is an operating mode of the 8060A in which the reference voltage for the a/d converter is applied to the a/d converter during both the integrate and the read periods. If the instrument is functioning properly, the display should read 10000 ± 10 counts (the decimal point location depends on the range, and does not affect the number of counts).

To select the ratio self-test, select a voltage or current function. Hold down the ➡◀))) button while you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the ➡◀))) button. The instrument should now be in the ratio self-test mode. To cancel the ratio self-test, press the ➡◀))) button or turn off the instrument.

If the count is within tolerance, it gives a strong indication that the a/d converter is working properly. If the count deviates more than 10 counts from 10000, the probable causes are as follows (in order of probability): a/d converter in U3, leakage around or failure of C16, 18, Z3, R8, or the power supply.

5-25. Switch Decoding Self-Test

To select the switch decoding self-test, hold down the REL button while you turn on the instrument. After the power-on self-test has been completed (the display is .8.8.8.8), release the REL button. The instrument should now indicate the switch decoding. To cancel the switch decoding self-test, turn off the instrument.

The switch decoding self-test indicates how the software in the microcomputer interprets the configuration of the eight switches and four push buttons. Each function or range that may be selected corresponds to a number that appears in one of the digit positions on the display (see Table 5-6). Notice that if no range is selected, the microcomputer assumes the 200 (μA, mV, Ω) range is selected.

In some cases it may be helpful to know that the microcomputer scans the switches in order from SW5 to SW8 (there is no input for switch SW4, the default range). The microcomputer assumes the first range switch detected as being pushed in is the desired range. For example, if you press in both the 200V and 1000V switches while in dc voltage, the microcomputer assumes you want the 200V range. There are two exceptions: diode test and conductance. If the microcomputer detects that the 2 kΩ switch is selected, it checks for the 20 kΩ switch (indicating diode test selection). If the microcomputer detects the 200 kΩ switch is selected, it checks for the MΩ switch (indicating conductance selection).

Also during the switch decoding self-test, the continuity indicator (the long bar across the top of the display) indicates the state of the continuity/frequency comparator. When the voltage at U3-4 (CM-) is less than at U3-3 (CM+), the continuity indicator is on. When the voltage at U3-4 is greater than at U3-3, the continuity indicator is off. You can use this feature to check the comparator when troubleshooting the continuity or the frequency functions. R9 controls the setting of the comparator offset.

Table 5-6. Switch Decoding Self-Test

Range	Display Digit 0*
200 (μA, mV or Ω)	0 (default if no range selected)
2	1
20	2
200	3
2000	4
Push Button	**Display Digit 1***
none	0
REL	1
➡◀)))	2
dB	4
Hz	8
Function	**Display Digit 3***
AC Voltage	1
DC Voltage	2
AC Current	3
DC Current	4
Resistance	5
Conductance	6
Diode Test	7

*Display digits are numbered 0 through 4 from right (LSD) to left (MSD).

5-26. Troubleshooting Guide

A troubleshooting guide is presented in Table 5-7. The guide is structured around the performance tests presented earlier in this chapter. To use this guide, complete the performance tests and note any discrepancies in performance. Then locate the test, symptom, and possible cause of malfunction in Table 5-7. When several possible causes of malfunction are listed, they are listed in order beginning with the most probable to the least probable. A section about troubleshooting the power supply is also included.

The following troubleshooting techniques can be helpful:

- When troubleshooting, remember to use the switch decoding self-test to determine whether the microcomputer properly interprets the function and range selection.

- Do not remove the main pcb from the bottom case unless you must do so to gain electrical access to circuits. You can gain electrical access to almost all of the input circuitry through the switch contact pins on the top of the switch deck (refer to the schematic in Chapter 8).
- One way to check the input circuitry is to attach a high impedance (>1000 MΩ) DMM at the input of the 8060A a/d converter, U3-6.
- You can do a lot of troubleshooting without the LCD and microcomputer pcb installed. Although there will be no display and the a/d converter and frequency counter will not work, the power supplies still work so you can check the input circuitry, the diode test and ohms sources, and the ac converter. Another advantage is that you gain access to all the pins on U3 without having to turn the main pcb over.
- You can troubleshoot the input circuitry with U3 removed (be sure to disconnect the battery before removing U3). Since U3 controls the power supply, removing U3 will cause the ac converter and diode test source to stop working. However, it will also eliminate any power supply leakages that might be affecting the input circuitry. Since the input protection, input divider and ohms reference resistors, amps protection, current shunts, and a/d input circuits consist of passive components (refer to the schematic in Chapter 8) you can check them without having U3 installed.

Table 5-7. Troubleshooting Guide

Test and Symptom	Possible Cause/Suggestions
Power On/Microcomputer and Display Test	
No display	Dead battery, battery connections, J4, power supply circuitry.
Missing LCD segments	Display interconnect.
All LCD segments stay on	Microcomputer connector, U5, U3, pcb lands open, C15 shorted.
Entire display is dim	Low battery, power supply low, display interconnect.
Some display segments are dim or ghosting	Display interconnect, contamination on pcb connector or LCD.

Table 5-7. Troubleshooting Guide (cont)

Test and Symptom	Possible Cause/Suggestions
Power Supply	
VDD (voltage between TP7 and common) ≠5.2 ±0.12V	U3, Q1, VR1
VDG (voltage between TP7 and TP8) ≠3.15 ±0.08V	U3, C21, U5
VSS (voltage between TP2 and common) ≠-5.1 ±0.27V	U4, C21, C23
TP4 ≠1.225 ±0.025V	
U3-11 ≠1.000 ±0.0004V	
	Hint: if you suspect U3 power supplies are bad, you can drive the 8060A power supplies externally. Remove battery, μC pcb, and U3. Apply +5.2V at TP1 - you can then check the ac converter, diode test source, VR2, U4, and the power supply circuitry.
Voltage Test - DC	
Gross error (constant reading of 0.00 or OL)	Perform ratio self-test in dc volts. If count is good, U3 is good. If count is way off, suspect U3, C9 R33, R8 Z3, C16 or C18
Ratio self-test passes, but constant reading of 0.00	R1, R2 (fusible resistors - replace with exact equivalent only). RJ1, RJ2, RJ3, RJ4 (varstors turn yellow when shorted), open circuit in front end, bad component is input divider, U3 pins 6 and 7 shorted. (Hint: check high impedance dc voltage first, which bypasses the input divider.) Refer to Table 4-1 for input divide rations.

Table 5-7. Troubleshooting Guide (cont)

Test and Symptom	Possible Cause/Suggestions
Voltage Test - DC (cont)	
High impedance dc readings 0.00 normal dc readings correct	R1
DC readings incorrect for all ranges	Leakage from pcb, U3-6/7, contamination
DC readings correct for 200 mV, 2V-incorrect for 20V, 200V, 1000V	Input divider or input divider switches, R2
Voltage Test - AC	
DC reading correct, ac readings incorrect	Switches S3D, S3B Check power supply connections J13 Vss J7 Com J12 Vdd
Resistance/Conductance Test	
All ranges incorrect	Ohms source voltage inadequate - using a voltmeter in the 2V or 20V range, measure ohms source voltage between TP11 and common. Refer to Table 5-8 for correct values. Q3, Q4, RT1, R2, R1, Z5 CR1 not supplying enough current (particularly if 200Ω range noisy). Select diode test, connect an external 1 kΩ resistor across the inputs and measure the voltage drop across the resistor - should be approximately 1V (±10%).

Table 5-7. Troubleshooting Guide (cont)

Test and Symptom	Possible Cause/Suggestions
Resistance/Conductance Test (cont)	
CR1 supplying proper current but reading off	Check values of the reference resistors for the range not working. Check voltage drops across the known and unknown resistors and make sure the ratio works properly.
Low range readings correct, high range readings off	Q3 and Q4 leak-check by seeing if MΩ reads OL with open input, or conductance reads 0 ±1.0 nS with open input. Main pcb contaminated - clean carefully and check performance.
MΩ range correct, but conductance not working	U3
Conductance reading >1.0 nS with open input	Main pcb contamination, U3 contamination
Current Test	
Constant reading of 0.00	Check fuses F1 and F2 with fuse check procedure in Chapter 2-4.
Fuses F1 and F2 good, but current readings off	Switches and resistors in current shunt.
High crest-factor ac current readings off	U1
Frequency Test	
AC volts readings correct, but frequency readings off	Check to see if ac signal at input arrives at U3-4 (inverting input to the frequency comparator in U3). If it is, check frequency calibration. If it is not, check R31, C27, Z7 and S1A.

Table 5-7. Troubleshooting Guide (cont)

Test and Symptom	Possible Cause/Suggestions
Frequency Test (cont)	
Frequency calibration is good and signal present at U3-4, but frequency readings off	Frequency compactor in U3 not responding. To check comparator, select switch-decoding self-test and apply input of 15 mV ac in the 200 mV ac range. Adjust R9 so that the continuity bar at the top of the display flashes off and on. If the bar will not flash, U3 is bad. If the bar flashes, but frequency readings are still off, U3 or U5 are bad. Check oscillation of crystal Y1 by measuring the frequency at U3-38 with another frequency counter - should be 40.000 ±0.020 kHz.
Continuity Test	
No response	Select switch decoding self-test - check for proper function decoding and also confirm that the continuity comparator responds. R31, S1A
No tone	Q6, R4, LS1. Check U3-1 (tone output) with scope for 2.667 kHz signal.
Diode Test	
No readings or very low readings	CR1 (diode test source). To check CR1, select diode test, connect an external 1 kΩ resistor across the inputs and measure the voltage across the resistor - should be approximately 1V (±10%).
BT Indicator	
BT indicator not displayed when battery voltage is less that 5.6V	U3, Z4-U3 compares voltage at pin 18 (BT1) with voltage at pin 10 (COM-analog common voltage). BT turns on if U3-18 voltage is greater than common. turns off if it is less (±50 mV)

Table 5-8. Troubleshooting the Resistance Function: Voltage Sources for Ranges

Range	Voltage Source (±10%)	Comment
200Ω 2 kΩ 20 kΩ 200 kΩ MΩ	4.5V 1.2V 1.2V 1.2V 2.1V	These values should be obtained when no external resistors are connected to the resistance inputs. Measure voltage between common (J2) and TP10. Note that the MΩ and 200 kΩ ranges will be loaded by a 10 MΩ input impedance. Use a high impedance voltmeter for the measurement or decrease the voltage source magnitude appropriately. A DMM with a 10 MΩ input impedance will read approximately 1.9V in the MΩ range.

Table 5-9. U3 (MAC) Pin Descriptions

Pin No.	Mnemonic	Description
1	Tone	2.667 kHz square wave to tone generator.
2 3 4	CFO CM+ CM-	Output, + input, - input, respectively, of the frequency/continuity function comparator.
5	VSS	-5.1V supply (externally generated).
6	HI	Input to the a/d converter.
7	LO	Sense ground for the a/d converter.
8 9	FC+ FC-	Connections to the "flying capacitor" which stores the reference voltage applied to the a/d converter during the read period. Plus and minus signs indicate polarity of stored voltage.
10	COM	Analog common.
11	VREF+	Input for 1V reference voltage for a/d converter and power supply.
12 13	OREF- OREF+	Reference input to a/d converter during autozero period for resistance and conductance functions.

Table 5-9. U3 (MAC) Pin Descriptions (cont)

Pin No.	Mnemonic	Description
14 15	BFH BFL	Output of the a/d buffer circuit.
16	AZ	Input for AZ capacitor.
17	INT	Input for INTEG capacitor.
18	BTI	Battery test input.
19	VIA	+5.2V supply feedback (nominally 1V)
20	CV	Gate drive for JFET. Series pass element
21	VDD	+5.2V supply.
22	VID	Reference voltage for the U3 and U5 digital power supply.
23	VDG	Output of the U3 and U5 digital power supply.
24 25 26 27	AD0 AD1 AD2 AD3	Four-bit parallel data bus between u3 and U5. During the first part of a data transfer operation they carry the address of the register being read or written to. During the remainder of the operation they carry data.
28	WR/	Register write strobe.
29	ALE/	Address Latch Enable.
30	RD/	Register read strobe.
31 32 33 34 35 36 37	IN10 IN11 IN12 IN13 IN20 IN21 IN22	SW5 SW6 SW7 Inputs to U5 indicating the switch SW8 positions. SW1 SW2 SW3
38	CLKO	40 kHz clock which drives the U5 clock input (crystal frequency divided by 80).
39 40	XTALI XTALO	Connections to the crystal oscillator.

Chapter 6
List of Replaceable Parts

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6-2. How to Obtain Parts 6-3
6-3. Manual Status Information 6-4
6-4. Newer Instruments 6-4
6-5. Service Centers 6-4

6-1. Introduction

This section contains an illustrated list of replaceable parts for 8060A True rms Multimeters. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Total quantity
- Any special notes (i.e., factory-selected part)

Caution

A * symbol indicates a device that may be damaged by static discharge.

6-2. How to Obtain Parts

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731. Parts price information is available from the Fluke Corporation or its representatives. Prices are also available in a Fluke Replacement Parts Catalog which is available on request.

In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Part number and revision level of the pca containing the part.
- Reference designator
- Fluke stock number
- Description (as given under the DESCRIPTION heading)
- Quantity
- Instrument Model, Serial Number, and Firmware Numbers

6-3. Manual Status Information

The Manual Status Information table that precedes the parts list defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

6-4. Newer Instruments

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a manual supplement which, when applicable, is included with the manual.

6-5. Service Centers

To contact Fluke, call one of the following telephone numbers:

USA and Canada: 1-800-44-FLUKE
(1-800-443-5853)

Europe: +31 402-678-200

Japan: +81-3-3434-0181

Singapore: +65-✻-276-6196

Anywhere in the world: +1-425-356-5500

Or, visit Fluke's Web site at www.fluke.com.

Ni-Cd *Note*

This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

⚠ Warning

This instrument contains two fusible resistors (pn 474080). To ensure safety, use exact replacement only.

Manual Status Information

Ref or Option No.	Assembly Name	Fluke Part No.	Revision Level
A1	Main PCB Assembly	865803	K
A2	Display PCB Assembly	538306	C
A3	Rms PCB Assembly	609120	A

Table 6-1. 8060A Final Assembly

Ref. Des.		Description	PN	Qty	Notes
A1	*	MAIN PCB ASSEMBLY	865803	1	
A2	*	DIGITAL PCB ASSEMBLY	538306	1	1
BT1		BATTERY,9V,0-15MA	696534	1	
F1	⚠	FUSE,.25X1.0,2A,250V,FAST	376582	2	⚠
F2	⚠	FUSE,.406,1.375,3A,600V,FAST	475004	1	⚠
H1		SCREW,PH,P,AM THD FORM,STL,4-14,.375	448456	2	
H2		SCREW,PH,P,THD FORM,STL,7-19,.750	447953	3	
H3		SCREW,FH,P,STL,6-32,.375	837682	1	
H8		WASHER,COUNTER SUNK,STAINLESS STEEL	614529	1	
MP1		BAIL-STAND, MED PEWTER	616961	1	
MP2		BRACKET,LCD MOUNTING	795112	1	
MP3		BUTTON,FUNCTION SWITCH-DK PEWTER	606889	3	
MP4		BUTTON, POWER SWITCH	456491	1	
MP5		BUTTON,RANGE SWITCH-DK UMBER	606871	5	
MP6		CASE,BOTTOM, MED PEWTER (CE)	664984	1	
MP7		CASE,TOP	538884	1	
MP8		COVER, BATTERY,MED PEWTER	649126	1	
MP9		DECAL, TOP CASE	535005	1	
MP10		TOP SHIELD	604801	1	
MP11		FLANGE, SWITCH	455881	1	
MP12		FOOT, NON-SKID	604397	4	
MP13		GASKET, LCD	605170	1	
MP14		CONN,ELASTOMERIC,LCD TO PWB,2..153	783191	1	
MP15		CONN,ELASTOMERIC,LCD TO PWB,1.35 L	587014	1	
MP17		LENS	612747	1	
MP19		PLATE, LCD	612762	1	
MP21		INSULATOR, SHIELD	604777	1	

Table 6-1. 8060A Final Assembly (cont)

Ref. Des.		Description	PN	Qty	Notes
MP22		SHIELD, LOWER	587048	1	
MP23		SHOCK ABSORBER,LCD	605188	1	
MP24		SHOCK ABSORBER	428441	1	
MP25		SPACER, CASE	458588	2	
MP27		SUPPORT, LCD	612754	1	
MP28		SUPPORT, TOP SHIELD	612770	1	
MP39		TEST LEAD ASSY, TL70A	855820	1	
MP40		BUTTON,FUNC,SW,DK PEWTER, MODIFIED	930347	1	
MP41		GUIDE,DMM ACCESSORY LIST	825851	1	
S10		SWITCH ELASTOMERIC4 POSITION	587055	1	
TM1		8060A INSTRUCTION MANUAL	609146	1	
TM2		8060A OPERATOR GUIDE	632679	1	
U3	*	FINAL TESTED PLASTIC PKG-8060	704759	1	2
U6		LCD, 4.5 DIGIT, MULTIPLEXED	799973	1	
W1		GROUND STRIP,BECU,1.980+-.035	817254	1	

1. THIS ASSEMBLY IS NON-REPAIRABLE. ENTIRE ASSEMBLY MUST BE REPLACED.
2. THIS COMPONENT IS INSTALLED ON A2 ASSEMBLY.
3. RECOMMENDED SPARE PARTS KIT PN 646705.

⚠ TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

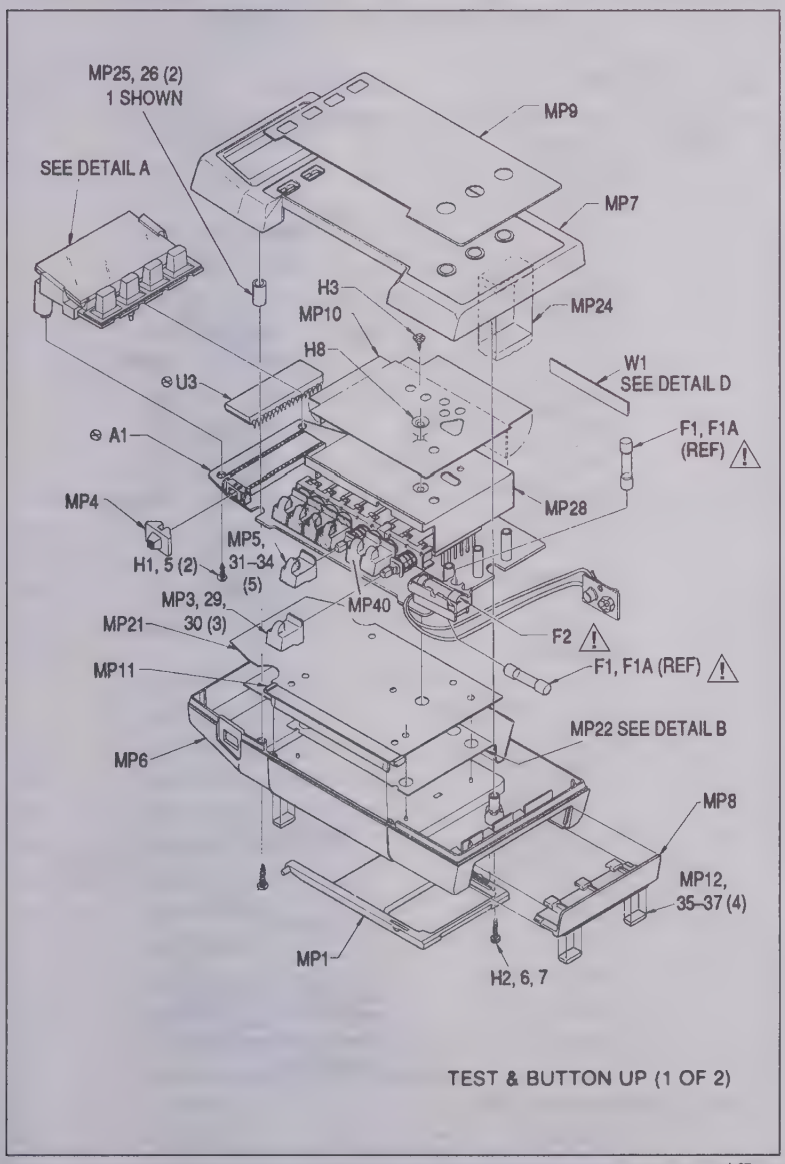

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Figure 6-1. 8060A Final Assembly

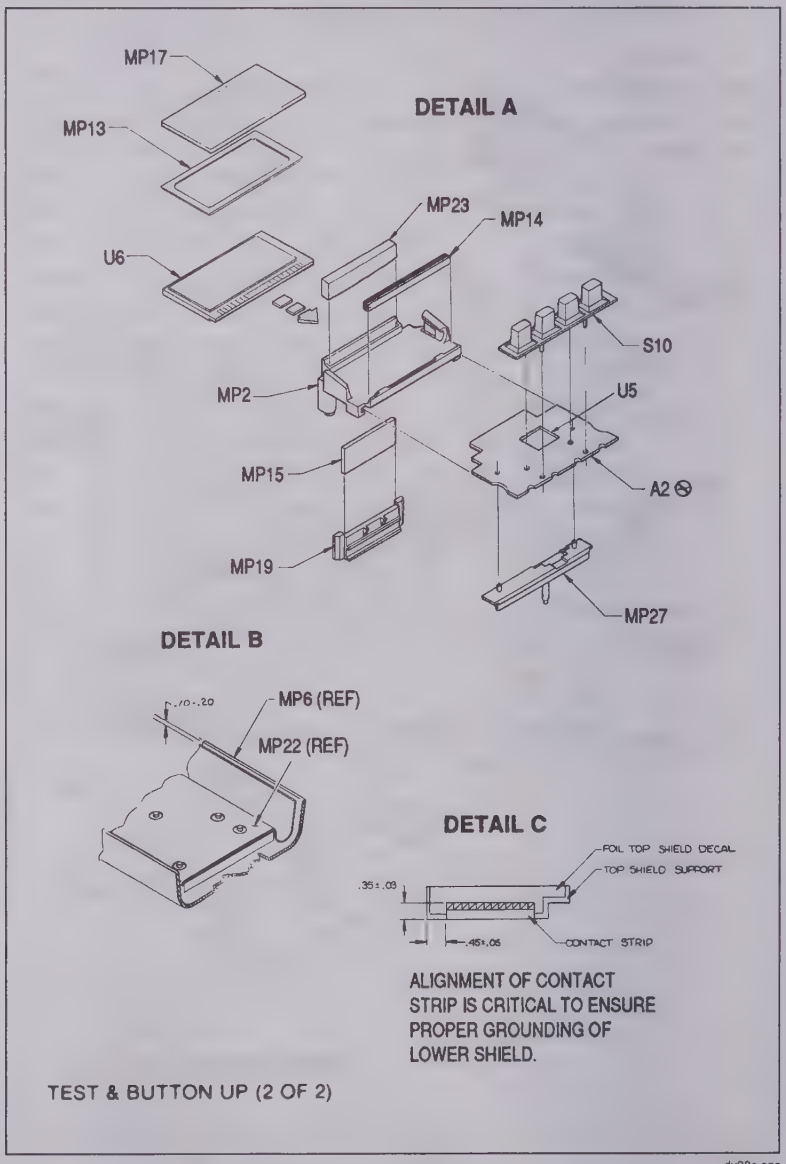

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Figure 6-1. 8060A Final Assembly (cont)

Table 6-2. A1 Main PCB Assembly

Ref. Des		Description	PN	Qty	Notes
A3	*	Rms PCB ASSEMBLY	609120	1	
C1,C23, C32,C34		CAP,AL,100UF,+-20%,6.3V,SOLV PROOF	615906	4	
C2		CAP,CER,8PF,+-0.25PF,1000V,C0H	643551	1	
C3		CAP,VAR,0.25-1.5PF,1700V,TEFLON	218206	1	
C4		CAP,CER,47PF,+-2%,100V,C0G	832295	1	
C5		CAP,CER,0.01UF,+-2%,50V,C0G	631044	1	
C6		CAP,CER,820PF,+-2%,50V,C0G	631002	1	
C7		CAP,VAR,4.2-20PF,100V,CER	631408	1	
C8		CAP,VAR,9-90PF,50V,CER	643130	1	
C9,C18		CAP,POLYPR,0.22UF,+-10%,160V	446799	2	
C10,C14		CAP,CER,0.01UF,+-20%,50V,Z5U	659045	2	
C11,C15, C33,C35		CAP,CER,0.22UF,+-20%,50V,Z5U	831982	4	
C12,C21		CAP,AL,10UF,+-20%,16V,SOLV PROOF	602326	2	
C13,C30, C31,C37		CAP,CER,0.01UF,+-20%,50V,X7R	816249	4	
C17		CAP,POLYES,0.01UF,+-10%,1000V	822361	1	
C16		CAP,TA,1UF,+-20%,35V	161919	1	
C22		CAP,POLYPR,0.1UF,+-10%,160V	446781	1	
C36		CAP,AL,22UF,+-20%,16V,SOLV PROOF	614750	1	
CR1	*	I-REG DIODE,1MA,10%,SEL,TO-226AC	334839	1	
CR2		DIODE,SI,100V,1A,DO-41	698555	1	
CR3,CR4	*	DIODE,SI,75V,150MA,DO-35	659516	2	
J1-3		RECEPTACLE	508606	3	
J4		JACK,PWB,RT ANG	423897	1	
J5		CONTACT ASSY TERMINATION	651653	1	
J6		PIN,SINGLE,PWB,0.025 SQ	603910	1	
J7-14		PIN,SINGLE,PWB,0.025 SQ	603910		
LS1		AF TRANSD,PIEZO,22MM,400UW,4KHZ	602490	1	
MP1		FUSE CASE	540716	1	
MP2		FUSE CLIP	534925	1	
MP3		FUSE CLIP	535203	1	
MP5		SPACER,SWAGE,.250 RND,BR,6-32,.687	544254	1	

Table 6-2. A1 Main PCB Assembly (cont)

Ref. Des		Description	PN	Qty	Notes
MP6		SPRING	535211	1	
MP12-15		SPACER,LED .330 LG	930342	4	
Q1	*	TRANSISTOR,SI,N-JFET,SEL,TO-92	721936	1	
Q3,Q4,Q6	*	TRANSISTOR,SI,NPN,60V,310MW,SEL,TO-92	886916	3	
Q5	*	TRANSISTOR,SI,NPN,30V,1W,TO-92	242065	1	
R1,R2		RES,MF,1K,+-1%,100PPM,FLMPRF,FUSIBLE	474080	2	1
R3		RES,CC,100M,+-10%,0.5W	190520	1	
R4		RES,CF,5.6K,+-5%,0.25W	442350	1	
R5		RES,VAR,CERM,2K,+-20%,0.3W	603753	1	
R6		RES,VAR,CERM,200,+-20%,0.3W	603738	1	
R7		RES,MF,154K,+-1%,0.125W,100PPM	289447	1	
R8,R15		RES,VAR,CERM,1K,+-20%,0.3W	614065	2	
R9		RES,VAR,CERM,100K,+-20%,0.3W	603761	1	
R10		RES,MF,1.62K,+-1%,0.25W,100PPM	772004	1	
R11		RES,MF,147K,+-1%,0.125W,100PPM	291344	1	
R16		RES,MF,383K,+-1%,0.125W,100PPM	288498	1	
R18		RES,VAR,CERM,100,+-20%,0.3W	614057	1	
R20		RES,CC,220K,+-10%,1W	109652	1	
R22		RES JUMPER,0.02,0.25W	682575	1	
R32		RES,CC,100K,+-5%,1W	641282	1	
R34,R35		RES,CF,12,+-5%,0.25W	442178	2	
R36		RES,CF,51K,+-5%,0.25W	376434	1	
R37		RES,CF,68K,+-5%,0.25W	376632	1	
RJ1-4		VARISTOR,430V,+-10%,1.0MA	447672	4	
RT1		THERMISTOR,RECT.,POS.,1K,+-40%	446849	1	
S1		SWITCH ASSY	535021	1	
S9		SWITCH,SLIDE,SPDT,PWB,RA	453365	1	
U1		DIODE BRIDGE,SI,50V,1A,DIP	418582	1	
U4	*	IC,VOLTAGE CONVERTER,10.5 V MAX,8 DIP	586248	1	
VR1	*	ZENER,UNCOMP,6.2V,5%,20.0MA,0.4W	325811	1	
VR2	*	BANDGAP REF DIODE, 1.22V, 35PPM	634154	1	
VR3	*	ZENER,UNCOMP,12.0V,10%,10.5MA,0.4W	741074	1	
XU3		SOCKET,IC,40 PIN,DUAL WIPE,RETENTION	756668	1	

Table 6-2. A1 Main PCB Assembly (cont)

Ref. Des		Description	PN	Qty	Notes
Y1		CRYSTAL,3.2MHZ,+-0.005%,HC-18/U	513937	1	
Z1		RNET,MF POLY,SIP,8060 HI V DIVIDER	539213	1	
Z2		RES,WW,NET,TOL MATCHED	461491	1	
Z3	*	RNET,MF,POLY,SIP,8060 LO V DIVIDER	611467	1	
Z4		RES,CERM,NET,TOL/TC MATCHED	614164	1	
Z5		RES,CERM,NET,TOL/TC MATCHED	614149	1	
Z6	*	RNET,CERM,SIP,8060 I SHUNT	737569	1	
1. FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.					

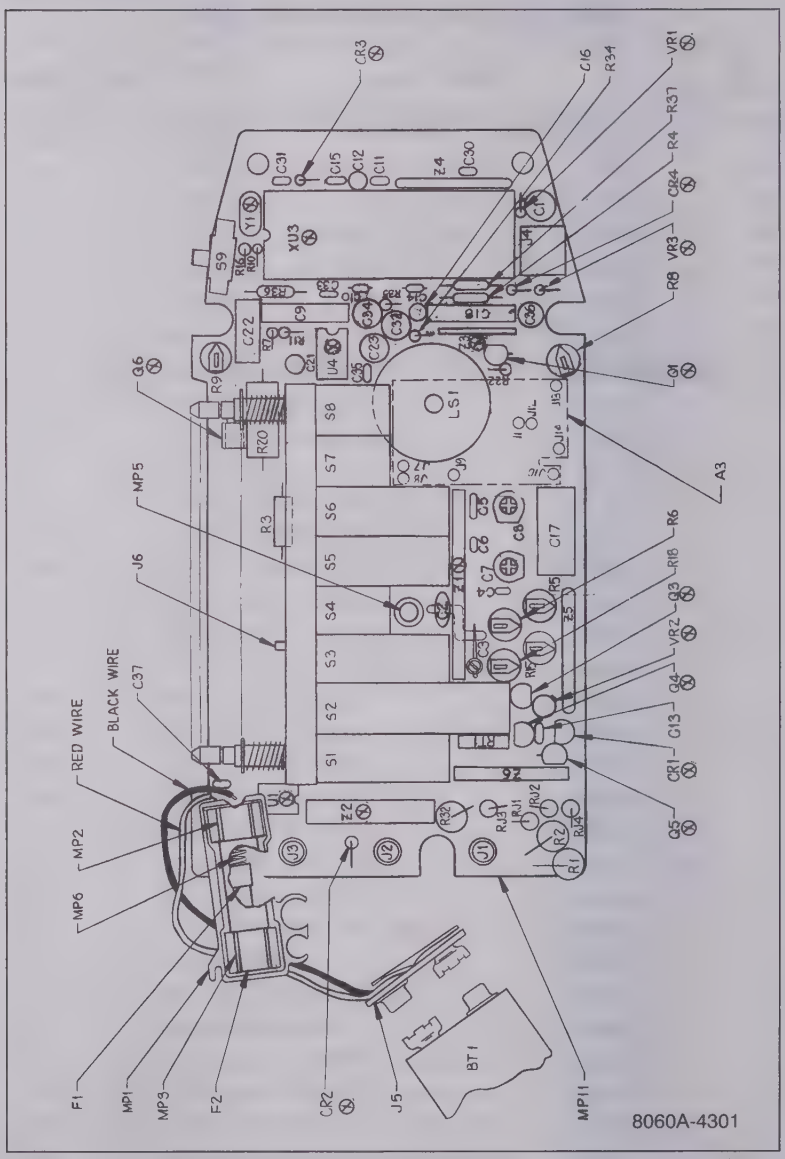

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Figure 6-2. A1 Main PCB Assembly

Table 6-3. A3 Rms PCB Assembly

Ref. Des		Description	PN	Qty	Notes
C1		CAP,TA,22UF,+-20%,6V,6032	876545	1	
C2		CAP,TA,2.2UF,+-20%,6V,3216	930248	1	
C3		CAP,TA,10UF,+-20%,6V,3216	105954	1	
C4		CAP,CER,0.1UF,+-10%,25V,X7R,0805	942529	1	
CR1	*	DIODE,SI,DUAL,100V,200MA,SOT-23	821116	1	
Q1	*	TRANSISTOR,SI,PNP,50V,225MW,SOT-23	820910	1	
R1,R2		RES,MF,10K,+-0.1%,.125W,25PPM,1206	106366	2	
R3		RES,MF,9.53K,+-0.1%,.125W,25PPM,1206	604873	1	
R4,R15, R16		RES,CERM,15K,+-1%,.125W,100PPM,1206	769810	3	
R5,R6		RES,CERM,200K,+-1%,0.1W,100PPM,0805	928882	2	
R13		RES,CERM,10K,+-1%,.125W,100PPM,1206	769794	1	
R14		RES,CERM,10M,+-5%,.125W,300PPM,1206	783274	1	
RT1		THERMISTOR,RECT,POS,1.5K,+-30%	822015	1	
U1	*	IC,OP AMP,BPLR,LOW VOS,PA IB,S08	689224	1	
U2		IC,Rms-TO-DC CONVERTER,200 MV,TO-100	604819	1	
U3	*	IC,OP AMP,FET,PREC,LOW PWR,SNGL S,S08	929828	1	
VR1		ZENER,UNCOMP,5.1V,5%,20MA,0.2W,SOT-23	837179	1	
VR2,VR3		ZENER,UNCOMP,3.3V,5%,20MA,0.5W,SOD123	641925	2	

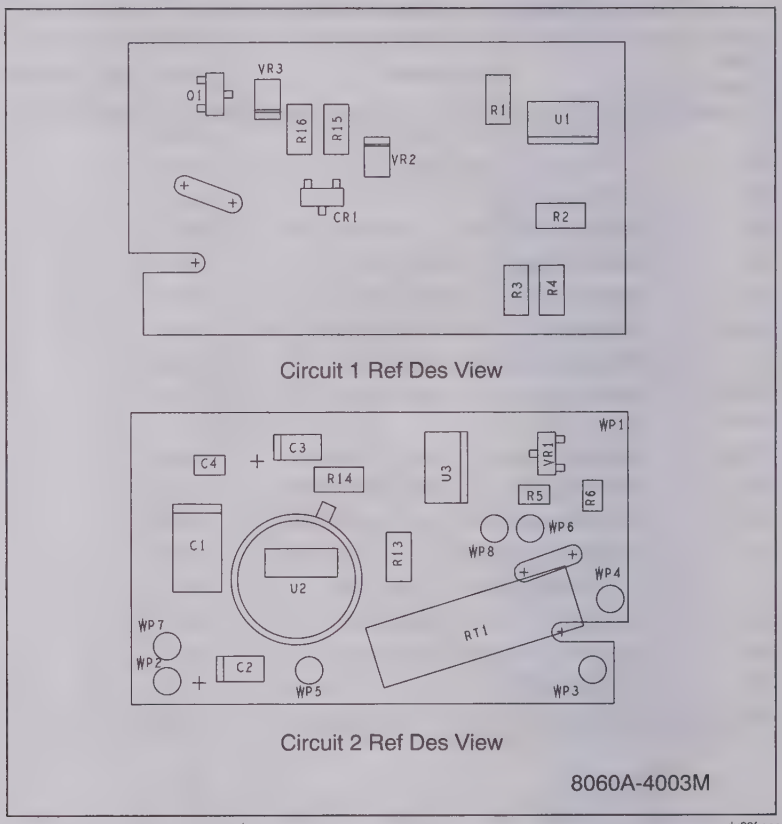

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Figure 6-3. A3 Rms PCB Assembly

Chapter 7
Schematic Diagrams

Figure	Title	Page
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7-2.	Test Point Locations	7-4
7-3.	A/D Measurement Cycle	7-5
7-4.	Switch Detail	7-5
7-5.	A1 Main PCB Schematic Diagram	7-7
7-6.	A3 rms PCB Schematic Diagram	7-8

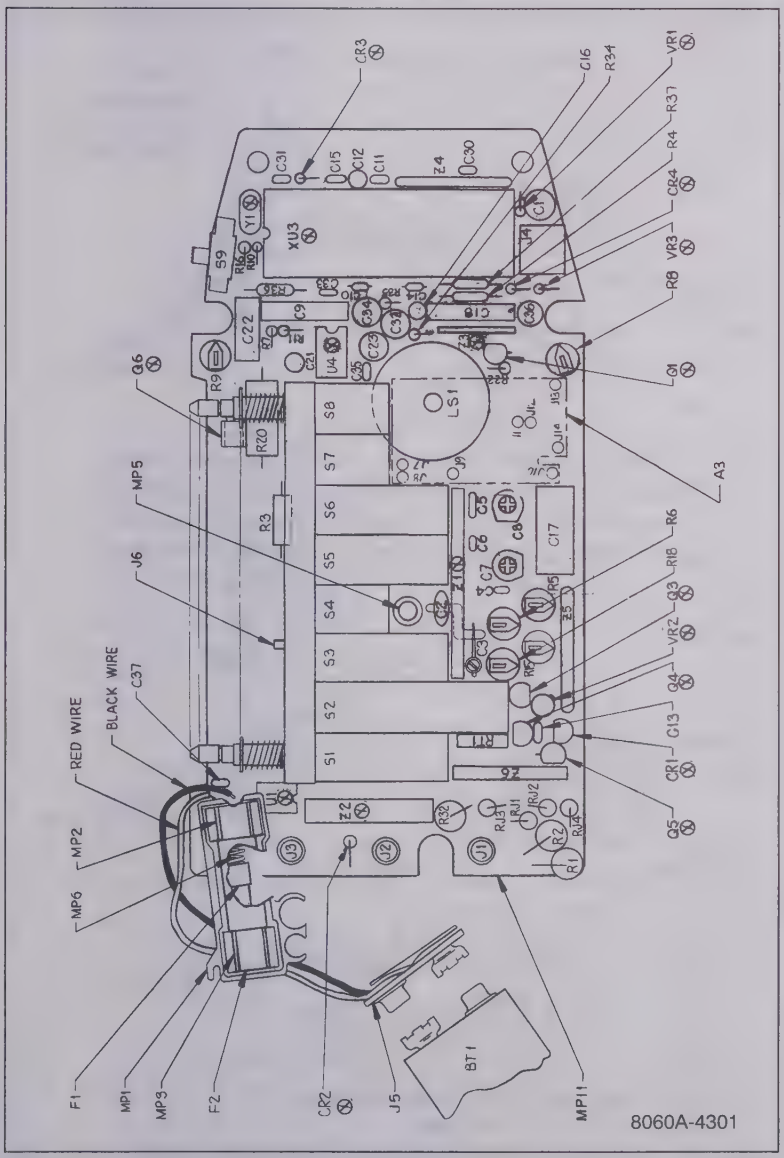

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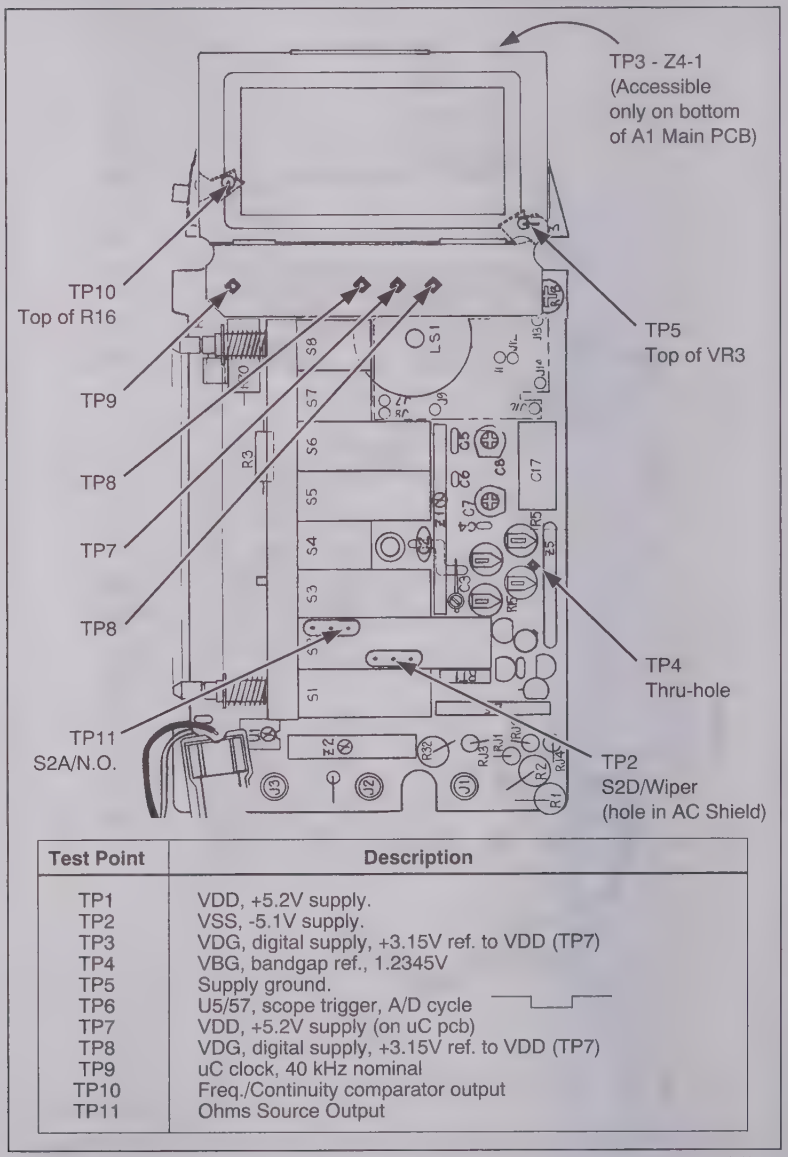
Figure 7-1. A1 Main PCB Component Locations



Test Point	Description
TP1	VDD, +5.2V supply.
TP2	VSS, -5.1V supply.
TP3	VDG, digital supply, +3.15V ref. to VDD (TP7)
TP4	VBG, bandgap ref., 1.2345V
TP5	Supply ground.
TP6	U5/57, scope trigger, A/D cycle
TP7	VDD, +5.2V supply (on uC pcb)
TP8	VDG, digital supply, +3.15V ref. to VDD (TP7)
TP9	uC clock, 40 kHz nominal
TP10	Freq./Continuity comparator output
TP11	Ohms Source Output

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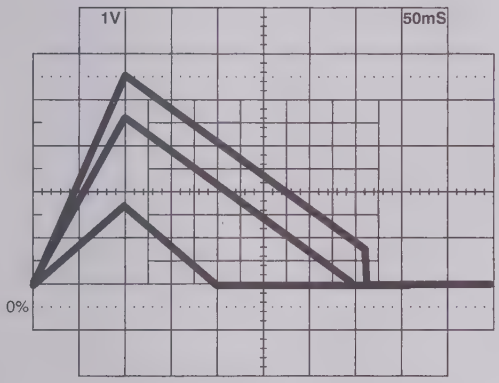
Figure 7-2. Test Point Locations



Shown, is the a/d measurement cycle for three readings: halfscale, fullscale and overrange (refer to Figure 4-3 and Section 4 for theory of operation). The three overlaid traces shown were made on a storage oscilloscope connected to U3-17 and triggered by TP6.

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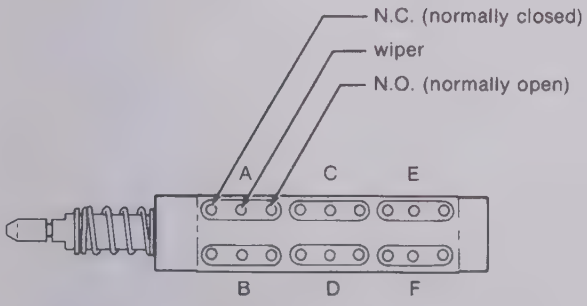
Figure 7-3. A/D Measurement Cycle



All switches are shown on the schematic in the "out" position.

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Figure 7-4. Switch Detail

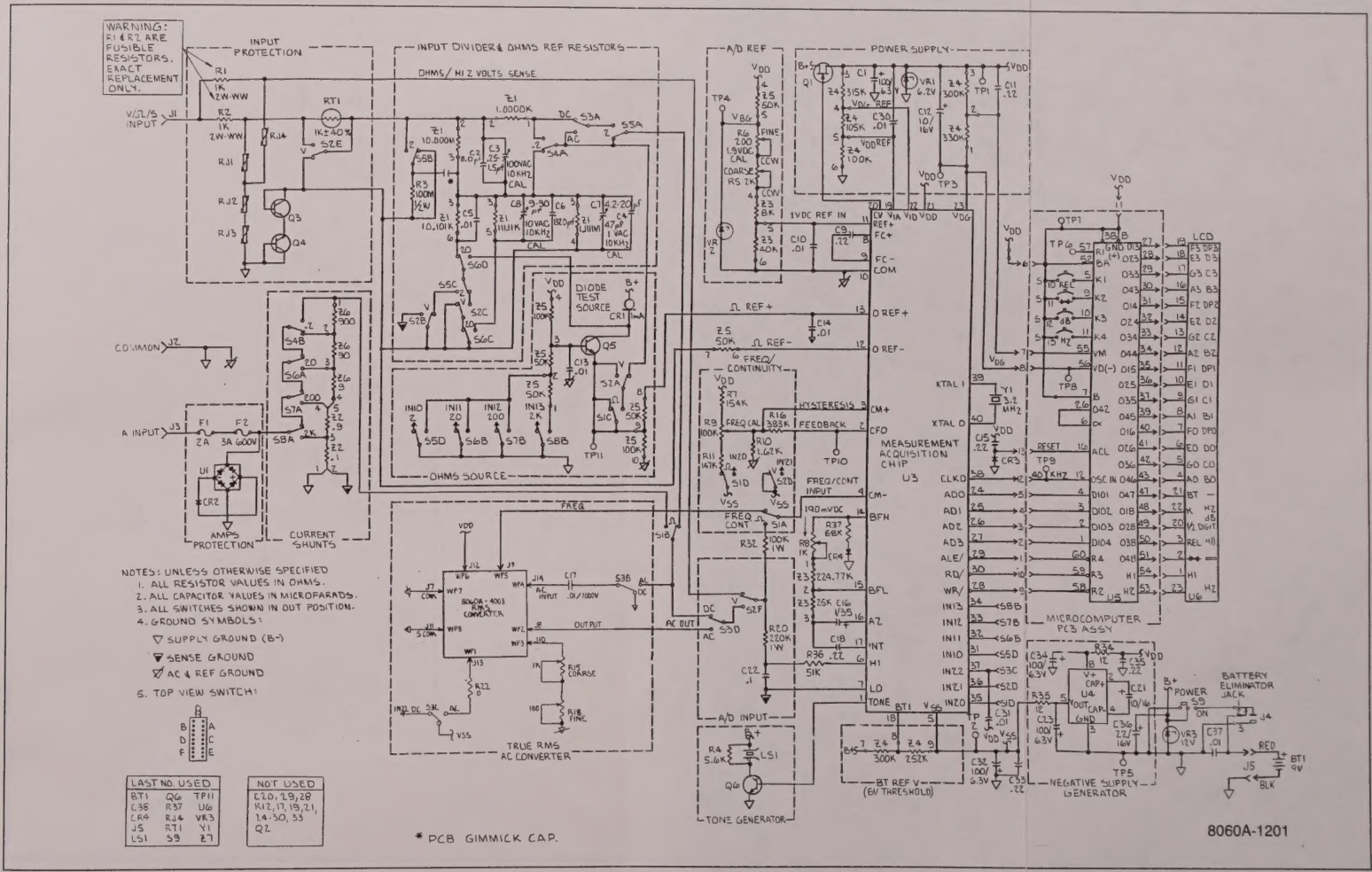

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Figure 7-5. A1 Main PCB Schmatic Diagram

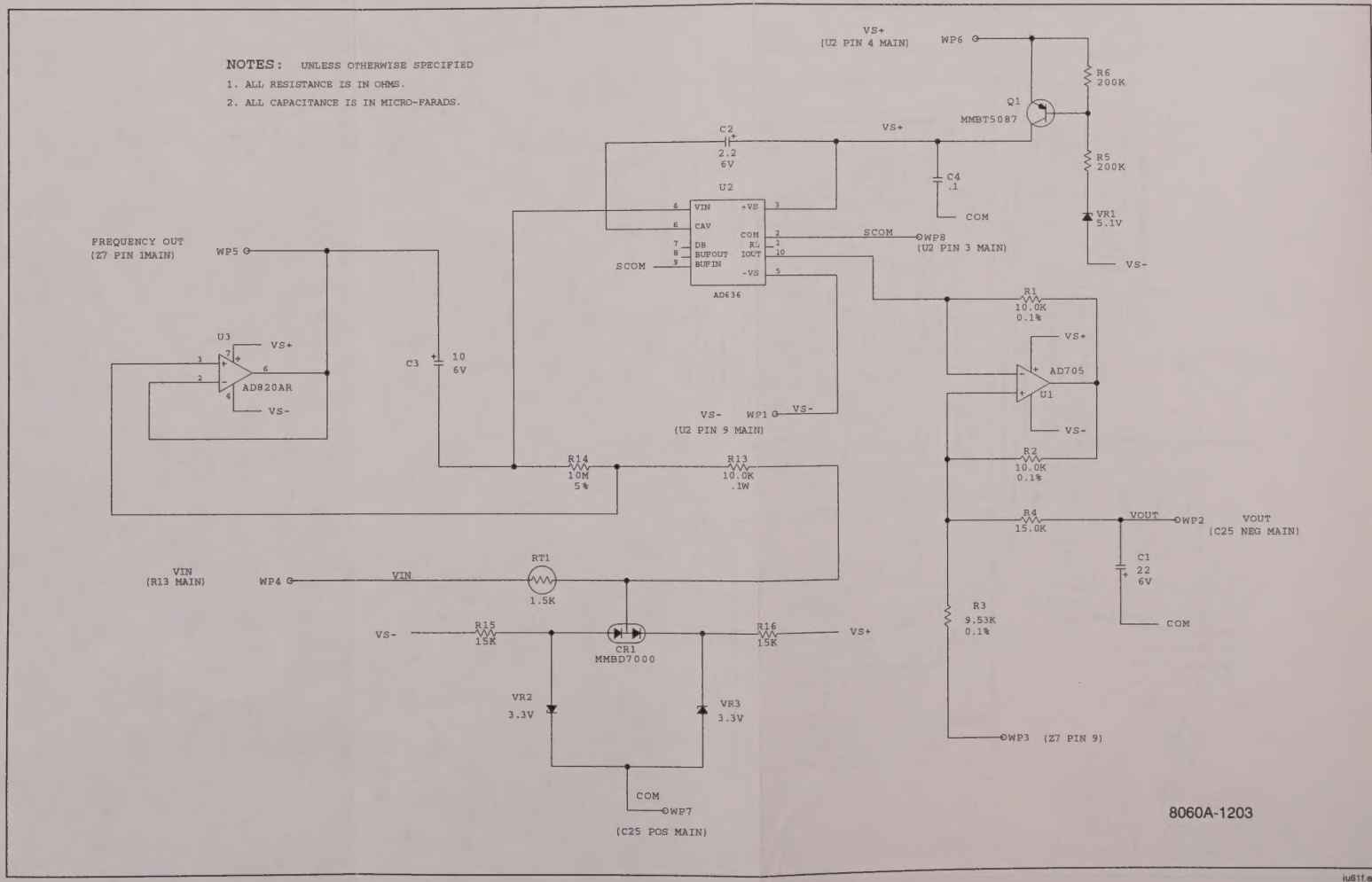

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Figure 7-6. A3 rms PCB Schmatic Diagram

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